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KEEPING THE MISSISSIPPI WITHIN HER BANKS.

By William Starling, C. E.

IT might be thought that of all the rivers in the world the Mississippi least needed improvement—that the drainage of a large part of a continent, with tributaries furnishing successive relays of water for the different seasons, with an immense volume, a gentle slope, and a climate that almost precludes obstruction from ice, ought to give a natural channel sufficient for all purposes of commerce. But navigable capacity is not the only thing demanded of a river—and furthermore this capacity is relative. What might be ample in a small stream with a confined and narrow basin may be altogether insufficient for a great waterway charged with the transportation of the products of twenty States. Most rivers are navigable enough during their season of flood. The freshets of the Mississippi are of very long duration it is true, —from about November to June,—but after they are past, the stream, just like a smaller one, becomes comparatively low. Unfortunately the demands upon the river remain as great at this time as at any other. The movements of grain, provisions, and general produce do not cease with the decline of the river. The only

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difference is that the freight must be carried in smaller cargoes at much greater expense, or leave the river altogether and be sent by rail. Does then the Mississippi go dry? Not at all. From one tributary or another there is always a considerable volume of water within the banks—enough to constitute a flood for a stream of very respectable size—but this volume is not distributed in such a way as to be most available or most convenient, nor are the banks and bed which hold it in such a condition as to satisfy those who live upon its borders or are dependent upon it in any manner.

The office of improvement of the Mississippi is sometimes merely conservative. Where the tendency is toward deterioration, that which fairly arrests such a movement may properly claim the name of improvement.

Now the radical vice of the Mississippi is its instability. The Mississippi proper, that is the portion containing the united waters of the Upper Mississippi, the Missouri and the Ohio, is commonly called the Lower Mississippi, and is considered as beginning at Cairo, Illinois. From this point to the Gulf of Mexico, a distance of about eleven hundred miles, the river runs entirely through its own flood-plain, which is exactly similar to a common creek-bottom; that is, it is the creation of the river itself, formed from the silt deposited by its waters in time of flood within a comparatively recent period. Consequently its banks are composed of sand, loam and clay, with no rocks and little gravel. The soil is mostly loose and friable. Hence it is very easily washed away by a strong current, especially when the current strikes it at an abrupt angle. The river being very crooked, a mere series of bends in fact, it is evident that the frequent changes of direction must often present the bank at an angle extremely unfavorable to its stability. Indeed, "caving banks" as they are called are among the most common and characteristic phenomena of the Mississippi. Let it not be imagined that "caving" consists in the mere scaling or sloughing away of small particles of earth. Acres go at a time and square miles disappear in a series of years. What now becomes of this mass of dislodged earth which overloads the already muddy waters? It cannot be carried far, so it is unloaded a few miles below under the lee of a projecting point of land. Mr. Smith's land in Mississippi, for example, has formed a *batture*, or accretion, to Mr. Jones' land in Arkansas. Not all of it however. Part has been dropped in the middle of the river where the current slackened after its violent shock against the bank and has formed a

shoal or "sand-bar." Even after disburdening itself of this load the waters are still charged heavily with earth and sand and continue to carry it in varying proportions to the sea.

As the plains which adjoin the river on either bank have been formed by deposits resulting from the overflow of the waters, it is evident that they cannot of themselves exceed or even equal the flood-height of the river. Indeed, it has been shown that the banks rather indicate the height of average floods, and that consequently all freshets greater than the mean must overflow them.

NOT QUITE SO BAD AS IT MIGHT BE.

We now see the nature of the evils which afflict the great river. Its banks are low and liable to be overflowed. They are friable, and subject to continual erosion on the one hand and accretion on the other. The bed is unstable and shifting and the channel liable to perpetual obstruction by shoals, which are not even constant in position but vary from year to year or even from day to day. These ills were for a long time deemed incurable, and even yet it is very hard to convince the old-time "swamper" that human wit can devise any remedy for them. A thousand times you will hear quoted the aphorism of the famous Prentiss, that "the Almighty

prescribed laws to every created thing except the Mississippi, and told *it* to do as it pleased." Indeed it might well daunt an engineer to measure forces with this formidable stream. Seen at the top of its flood, its vast expanse of sullen yellow water swirling and boiling along in perpetual eddies, with a current of from five to six miles an hour and reaching far above the natural level of its banks, almost to the very top of the slight, frail-looking embankments that strive to confine it, it is majestic, imposing, and awful. It is with the Mississippi as with the sea—those who know it best respect it most!

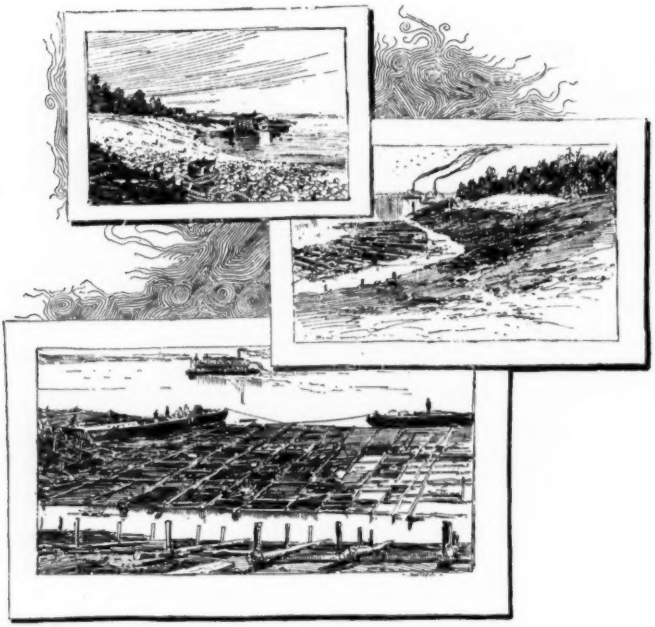
The Mississippi acts upon such a tremendous scale that undertakings looking to its control are enormously expensive. Even experiments cost vast sums of money, for to be of any real use they must be made upon the spot. Observations on twenty-foot canals or even on small rivers frequently lead to conclusions which are misleading when applied to the Mississippi. Not only the expense but the precarious nature of work upon a river with such an unstable regimen for a long time deterred action upon it. The mouth, of course, from its great consequence to the shipping trade of New Orleans and of the whole Mississippi Valley first demanded attention. The triumphant success there of Mr. James B. Eads' jetties seems to have drawn public attention to the practicability and expediency of the amelioration of the whole river. In 1879 the Mississippi River Commission was organized under an Act of Congress, and has been at work ever since. The first thing to be done was to have an accurate survey made. This was accomplished with all necessary precision between 1879 and 1882, and the results are visible in two admirable series of charts, the larger of which on a scale of one to twenty thousand presents, besides ordinary topographical features, the contours of the adjacent country at intervals of five feet, and the hydrography of the river at stations one-half mile or more apart. The smaller series on a scale of one inch to the mile is sufficient for ordinary purposes.

The nature of the improvement projected by the Mississippi River Commission and now in process of execution will easily be understood from what has been said of the river. That the stream with its vast capacity may be made to do the good of which it is capable and restrained from doing the harm to which it is prone, three things are necessary. The channel must be deepened where it is shallow and fixed where it is shifting. The banks must be

prevented from caving. The flood-waters must be restrained from overflowing the banks. These objects seem to be independent and to refer to different interests, but they hang curiously together and neither can be properly undertaken without involving the others. Accordingly, all have received a share of attention from the Commission. In the prevention of overflow they have acted in concert with the local authorities. In the other classes of improvement they have relied entirely upon their own organization.

In giving depth and stability to the channel, it must be remembered that the volume of water in the Mississippi even at the extreme low stage, would be abundant for purposes of navigation were it properly disposed. This river like all others is divided into pools and shoals, of which the pools are narrow and the shoals wide. Even the low-water cross-section of the Mississippi is something like fifty thousand square feet, which with the average low water width of about three thousand four hundred feet would give a mean depth of fifteen feet, or more than is required by the class of vessels now in use upon the river. The shoals however are frequently from six thousand to ten thousand feet wide, and the bottom "lumpy," as the steamboatmen say; that is, the channel is not continuous but full of alternate bumps and hollows; it is tortuous and very hard for the pilot to find. Frequently indeed, there are several channels, some sufficient, some entirely inadequate, and that which is good to-day may be useless within a week. It is very evident that if the width could be reduced say to three thousand feet, there would be ample depth at all times and the channel could be confined within moderate limits. The obvious expedient then, is to contract the width of the river at the broad places and to force the water to use a narrow channel. This is the identical process resorted to with success at the jetties in the mouth of the river.

Usually there is no great difficulty in applying this method to the wider reaches. Very often the work is facilitated by the existence of an island. It has long been remarked that the current is prone to split itself into two divisions in wide straight reaches, and islands form themselves between the splits. To effect the desired contraction, the engineer chooses the channel which he thinks the proper one to be preserved, and proceeds to close the other. Thus the river is often brought to the required dimensions by this single operation, the passage chosen for obstruction being of



UPPER-BANK REVETMENT, LOUISIANA BEND.

MAT, GRADED BANK, AND UPPER-BANK REVETMENT.

MAT COMPLETED READY FOR BALLASTING.

course the smaller and less important of the two. This minor channel is called the *chute* of the island. To close the chute it is sometimes sufficient to drive a pile-dike, consisting of several rows of piles, across the head of this smaller channel,—the retardation of the current produced by this obstruction being sufficient to cause a heavy deposit of the sediment held in suspension by the water, which ultimately results in the formation of a shoal so considerable as entirely to bar the passage of water at low stages. If one dike is not enough several are placed at convenient intervals apart, their bottoms being protected from the *scour*, or tendency of the current to wash out a deeper channel, by "foot-mats,"—a sort of carpet made of poles and brush, weighted with stone and sunk in their proper position, in front of, behind, between, and around the piles.

Where there are no islands, extensive systems of pile-dikes

must be built out from one or the other shore, encroaching on the channel-way and compelling it to contract itself.

From these examples a glimpse may be had of the principle followed in planning all river-improvement,—that is, to make use of the immense destructive and reparative forces constantly exerted by the river itself and turning them to the profit of the engineer.

The effect of an encroachment on one side is very soon felt on the other, the increased current due to the contraction causing extensive "caving" unless precautions be taken against it. So here we are at once concerned with what was declared to be the second main object of river-improvement. For a long time this was considered a desperate undertaking and the old inhabitant had his say about it with more than usual vehemence and positiveness. Very triumphant was he when the first feeble attempts resulted in failure. After many experiments, however, bank-protection is now practised with success, the task being more or less arduous and the work more or less costly according to the difficulties encountered. The hardest bank to protect is where the material consists of almost pure sand and is exposed to a strong current at an abrupt angle.

The processes in use are two—a continuous revetment, and detached submerged dikes. The method pursued in the first case is to weave a mat or carpet of poles and brush, wide enough to cover completely the part of the bank subject to erosion, extending from near the top to a little beyond the extreme depth of the bottom, weighting it with stone so as barely to allow it to float, then suddenly sinking it by throwing on large quantities of stone distributed as evenly as possible until it rests entirely on the bottom. The "weaving" is a literal imitation of that process, and is performed on ways or temporary supports upheld by a barge placed perpendicularly to the river. The warp or standing portion composed of poles rests on the ways. The web of willow brush is then passed alternately over and under the poles until a fabric is produced resembling a rough basket-work. This is strengthened by iron rods and cables in every direction and secured by a checker-work of poles laid on top and fastened to the mat by twisted wires, making a series of squares and serving the purpose of stiffening and strengthening the mat and retaining the covering of stone. This "subaqueous revetment" is afterwards supplemented by an "upper bank revetment" laid upon the portion of the bank out of water, which has been carefully sloped away for

that purpose, usually by means of a powerful jet of water worked from a floating pump. The mat thus woven is laid continuously over the whole stretch of bank to be protected. The cost is from $100,000 per mile, upward.

The method of submerged dikes differs from this in principle. The dikes themselves are long and narrow cribs, broadest at bottom and tapering to the top, placed perpendicularly to the bank and sunk in that position. They are high enough to obstruct materially the flow of the water over them and thus to stop scour and even induce deposit. They are spaced about four hundred and fifty or five hundred feet apart. Each crib rests upon a narrow mat as a foundation.

Each of these methods has its advantages and its drawbacks. The continuous revetment is doubtless the best in very bad situations where it may be made of almost any desired strength and weight. The dikes are better adapted to banks of tolerably strong material and which cave comparatively slowly. They may be placed at longer intervals and may thus be made to cover a greater distance. By the one method or the other it is thought that any caving bank no matter how bad may be protected. A signal instance of the success of the dike-method is presented at the town of Greenville in Mississippi. For many years this bank had been breaking away at the rate of about one hundred feet a year. Consequently the town had hardly a substantial existence and lived by a very precarious tenure. No one dared to build a substantial house, for he might have to move it in three or four years. There was no encouragement to undertake any permanent improvement —paving, waterworks, factories. In 1886 Congress made an appropriation for the improvement of Greenville harbor, which was supplemented by the issue of bonds to a still greater amount by the town, and the work of protection was begun and partially completed in the winter of 1887–1888. The end aimed at has been secured and the town has now a permanent site.

Bank protection, either for its own sake or as auxiliary to contraction works, is of constant and increasing application, and the successful practice of it is one of the most valuable of the results achieved by the present school of Mississippi River engineers. One of the latest and most important uses to which it has been put is for the prevention of cut-offs, or breaches through the narrow necks of land at the big bends in the river, to which for the present a bare allusion must be made.

For protection against inundation many remedies have been proposed; in fact the newspapers are teeming with them, especially during the time of great floods. Reservoirs at the headwaters of the principal tributaries to hold back the freshets; cut-offs to increase the current and hence lower the water line; outlets to draw off the superfluous volume—and finally embankments to enlarge artificially the capacity of the river-bed, are examples of the suggestions made. In estimating the merits of these different plans non-professional persons especially are apt to lose sight of the fundamental principle of the regimen of rivers like the Mississippi, that is, of silt-bearing streams flowing through beds of their own formation:—that this regimen is self-adjusting and that any violent or forced departure from it either cannot be permanent or will introduce compensatory changes elsewhere. Thus, cut-offs will produce increased caving and building of banks and bars above and below them, and will end, after doing infinite damage, in restoring the river to its former length. Outlets will induce a shallowing of the

THE BALLASTED MATS IN POSITION.

river and a raising of the bed, and consequently of the water-line. In short, the only one of the remedies above mentioned that is satisfactory to those concerned or that has had any extensive application, is the method of artificial embankments or levees.

The levees of the Mississippi River are not a continuous system, but are composed of several independent parts appertaining to the great "basins" into which the Lower Mississippi Valley is divided. The low hills which bound the Valley approach the river at several points forming conspicuous bluffs and isolate the portions of alluvial land included between those points one from another. Thus, the Yazoo Basin is bounded on the North by the Memphis bluffs and on the south by those of Vicksburg. These form natural resting-points for systems of levees and permit the isolation of one system from another; a great convenience, as it renders unnecessary great concerted efforts and allows each community to protect itself as its means suffice.

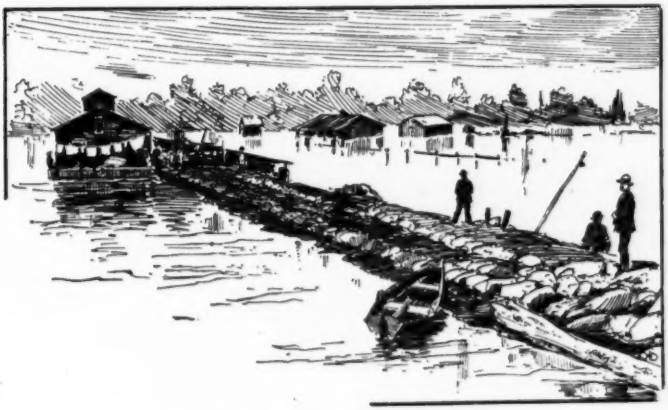
The levees are simple earthen embankments, built as high and

as strong as the resources of the different districts will permit. They have sometimes been criticised for their insufficient dimensions, as if these were the result of bad engineering or of injudicious parsimony. Inadequate as they may be they are the result of very severe taxation. None are so well aware of their deficiencies as those who maintain them, and they are being improved every year though they still lack a great deal to make them complete.

As another instance of the close relation existing between the different branches of river improvement, the levees which were begun by the local communities for protection against overflow are regarded by the Mississippi River Commission as essential adjuncts to the improvement of the navigable channel. As outlets of any kind deteriorate a silt-bearing river, likewise confinement of its waters improves it, by increasing the volume, the velocity, and hence the scouring and transporting power, with a comparatively slight increase of the burden of silt. Wild or unconfined streams habitually raise their beds. Perhaps it is too much to say broadly that confined streams do not, for the evidence is scanty and the circumstances present a very wide range of difference; but if they do, it is only in small measure and far less than in their wild state. In the case of the Mississippi the evidence shows that the bed has not been raised at all in the leveed portions, and that it has been raised in the unleveed. It will be evident that the co-operation of Government and local organizations in the matter of levees, before alluded to, by which the Government have contributed since 1882 a considerable sum for levees, though not more than about one-third I think of that expended by the riparian communities—is a matter of great importance for the proper control of the river as a whole.

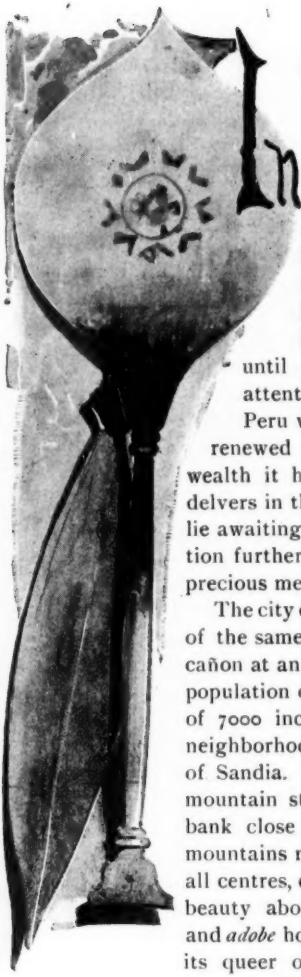
The maintenance of an imperfect levee system in the face of a great flood is an arduous task. The embankments are deficient in height and strength. Many are old and unsound, full of decaying stumps and roots and penetrated perhaps by cavities. Leaks break out that have to be stopped, in one way or another; the wet earth begins to slough or slip on the land side; the brimming river creeps higher and higher until it threatens to overtop the puny dike; finally comes a howling "norther" with rain or sleet, bringing breakers almost like the surf of the sea, which cut the earth into fragments and suck it away with the undertow. Against these the best improvised remedy is found to be sacks filled with earth and placed carefully in position. The accompanying engraving is

from a photograph taken after the partial recession of the water, of one of these storm-battered levees, where, alas! after all, the dreaded calamity called a "crevasse" has occurred and the water is seen nearly as high inside as outside. Beneficent Uncle Sam has sent one of his "quarter-boats" to the relief of the poor drowned-out people, who are sheltered partly on it and partly under temporary sheds built on the levee.



SKIPWITH LEVEE AFTER THE CREVASSE.

Great progress has been made, however, in levee-building as in all the other branches of river improvement. Experience has taught many salutary lessons in all departments, and where ten years ago we trod with cautious and tentative steps, we now proceed boldly and with the assurance of success.



GOLD MINING IN PERU BY THE INCAS.

By E. E. Olcott, E. M.

In one of the most remote regions of Peru, far up in the Sierra, accessible only by narrow and broken roads, are situated the famous provinces of Carabaya and Sandia, known by the former name only until 1875. The region has attracted attention from the earliest period in which Peru was explored and is now claiming renewed interest, because in spite of the wealth it has already yielded to the patient delvers in the earth, it is hoped that there yet lie awaiting the touch of the present generation further and possibly even vaster stores of precious metal.

The city of Sandia, the capital of the province of the same name, is situated in a picturesque cañon at an elevation of 7250 feet. It has a population of about 700 within town limits and of 7000 including dependent pueblos in the neighborhood, all controlled by the Governor of Sandia. Through the cañon flows a limpid mountain stream, the Inambari, and upon its bank close under the shadow of the green mountains nestles the little town, remote from all centres, difficult of access, but with a quaint beauty about its irregularly-disposed stone and *adobe* houses with their thatched roofs, and its queer old church, and an exhilarating grandeur in the vista through the cañon and across intervening valleys to the more remote chains of the Cordillera. To reach Sandia one must first travel for two days by sea, south from Callao, the seaport of Lima, thence eastward by a rail-

road journey of four hundred miles, and after that twenty-eight leagues must be traversed on mule-back before coming to the city. Nor must it be imagined that this latter part of the journey is performed over good roads. On the contrary they fully justify the description given by Mr. Clement R. Markham, who says: "The roads of Sandia are bad; in their best places, they are like steep back attic stairs after an earthquake." This, observe, in the *best* places. In others there are absolutely *no* roads, and the traveller must make his way through bush and bramble as best he can, sometimes on the sides of steep valleys like the Puli-Puli, where the only footing possible is in the yielding moss, through which one must proceed step by step clinging to the branches of trees and to vines. Add to this that there are no bridges, that it is impossible to get beasts of burden into many of the localities, that the streams must therefore be waded with all one's clothing on, and a faint conception may be formed of the difficulties attending travel in this region. Were it not for the woollen clothing, including woollen moccasins in shape not unlike bathing-shoes, it is hard to see how foreigners could ever bear the exposure. The natives cover their heads and faces during these mountain journeys with a curious helmet-like mask knitted by the women, with skilfully shaped openings for eyes, nostrils and mouth, and these doubtless often save them from death by freezing. Several leagues further up the cañon from Sandia is found the picturesque Indian village of Cuyo-Cuyo, at an elevation of 11,310 feet. This is the residence of the governor of the community. A number of outside towns are dependent on this central one, the whole population being some 4000, only ten per cent. of whom live in Cuyo-Cuyo itself. There is good military discipline, and at the call of the governor the Indians leave their homes and congregate in the village to perform the duties required of them. The character and customs of these aborigines are quite worthy of study.

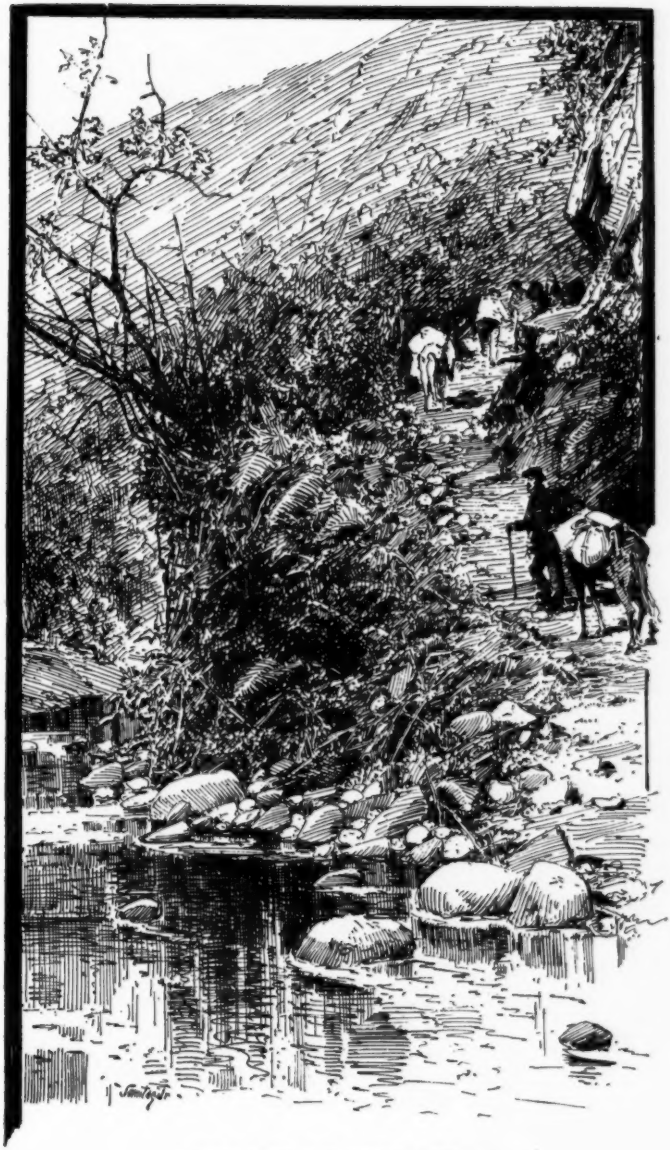
They are descendants, more or less pure, of the Incas—their language being the Quichua, that expressive, beautiful and complete idiom the vocabulary and construction of which attracted the attention of no less important a man than Francisco Fernandez de Cordova, as we find by his allusions to it in the famous appeal for clemency to the Indians which he addressed to Philip II. in 1560. It is a difficult language to learn, abounding in very hard guttural sounds until it seems as if one would snap his vocal cords in the effort to pronounce some combinations of letters. Names of places and

things have nearly always some signification; for example, "Huach-accuya," signifies "the place for the poor man," and is given to the richest spot in the district of Ancocala. The nouns are declined and the verbs are conjugated. The numerals are as follows: one, *huc;* two, *yzcay;* three, *quinza;* four, *tahua;* five, *pichca;* six, *zocta;* seven, *camchiz;* eight, *puzac;* nine, *yzcon;* ten, *chunca.* The combinations for larger numbers are somewhat appalling to foreign ears, one hundred and ninety-one, for instance, being represented as *pachac igzoonchunca hucniyoc.*

Like all semi-civilized tribes the natives have some child-like qualities, both good and bad. Our own experience enables us to feel justified in saying that they are tractable and industrious, and that among them are as good workmen as ever handled tools. They are skilled in gold washing, and excellent manipulators of the *batea*, or native pan for gold-washing.

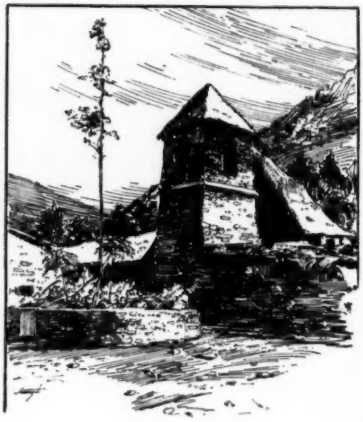
One bright fellow in our employ for several months was José Murgia, or Chepe as he was called; a more industrious, intelligent, contented worker it would be impossible to find. With perfect ease he would wash two hundred *bateas* of dirt in ten hours, and laugh at its being considered a special feat, and this at wages of forty-five cents United States currency per day. They respect industry and faithfulness. Positions are given by the local government to those who prove themselves worthy, and there is a special term of reproach for one who undeservedly holds a high position without having gone through other posts leading thereto. They are sometimes difficult to trade with, and will not sell at any price what the foreigners want; and one stratagem resorted to is to throw money on the ground, when the love of money—not confined to the Indian tribes—nearly always leads the native to seize the coin, but not without giving its fair equivalent. This represents our own experience with them; but that opinions differ on this as on every subject may be shown by the following paragraph, quoted in Guillaume on the Amazon Provinces of Peru, from Señor Antonio Raimondi:

"The Quichuan is always submissive to your face, but slow to perform; soured by ill-treatment, he will hardly do anything unless he is compelled. He will do nothing unless he is treated as a slave. Treat him kindly and you will make him a thief; whip him and he will rise up and thank you and be your humble servant. Servile and timid, superstitious and indolent, the Quichuans have not half the spirit of the North American Indian. It has passed into a proverb, 'the Indian lives without shame, dies without fear and eats without repugnance.'"



UP THE MOUNTAIN TO THE GOLD REGIONS.

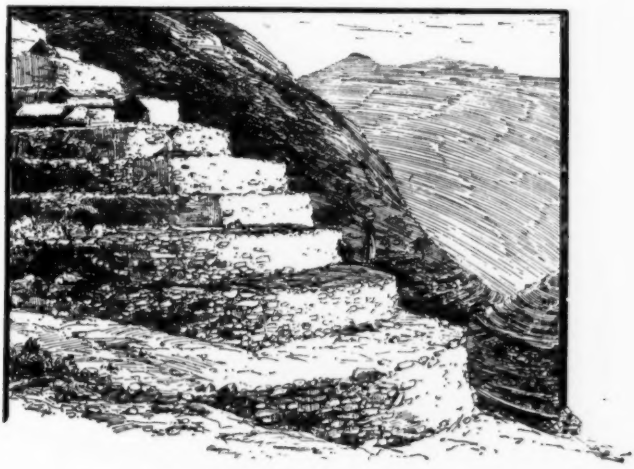
These people have from early times cultivated the soil in the face of difficulties which might well have proved insurmountable. To secure any soil it was found necessary to make terraces on the mountain sides. These are still found throughout the mountain provinces, running up hill-sides of more than a thousand feet of vertical elevation, where it was often necessary to erect stone walls ten feet high in order to get twenty feet of level ground in which to plant their potatoes and barley. The patience thus exhibited is marvellous. Our common potato which we have called "Irish" since it was brought back to its native shores by our forefathers from the land to which Sir Walter Raleigh had conveyed it from the new world, is indigenous to South America and is the great article of diet in every Indian household. Each man holds from the community certain agricultural lands, and raises the two crops which are essential to his existence, namely, potatoes and coca. The potatoes are planted in the proper season by each man followed by his wife and all the children who can walk. The man turns over the ground with a spade of remarkable construction, the handle fully six feet long; the woman and children follow, breaking up the lumps of earth with crooked sticks or stone hammers lashed to wooden handles, and dropping the seed. Once planted the field is abandoned to the mercies of Dame Nature until it is time for the earth to yield her increase. No robber enters the unfenced field, no stray cattle molest it, for by custom or unwritten law "Indian don't rob Indian," and cattle are always tended by herdsmen during the day and corralled at night. A mule's load of potatoes is often sold for fifty cents. When soaked, frozen and dried, and thus formed into the valuable food "chuño," a hundred pounds is worth seventy-five cents,—and will go a long way with a foreigner.



CHURCH IN SANDIA.

More important than even the potato is the coca, which is grown in the warm valleys of the Montaña at any elevation less

than 4000 feet. To be either contented or useful every Indian must have an abundant supply of his coca. The dried leaves, which have somewhat the taste of tea, are held in the mouth between the gum and the lip until the saliva has extracted all the active principle of the plant, when the supply is replenished. The effect of the coca habit is peculiar. Its votaries become more addicted to its use than does the most inveterate chewer or smoker to his tobacco, and with plenty of these leaves the Indians go uncomplainingly from twelve to fourteen hours without any food. The effect seems to be to absolutely allay hunger and even temporarily to stimulate. There is no question as to the agreeable and



A MOUNTAIN TERRACED FOR CULTIVATION.

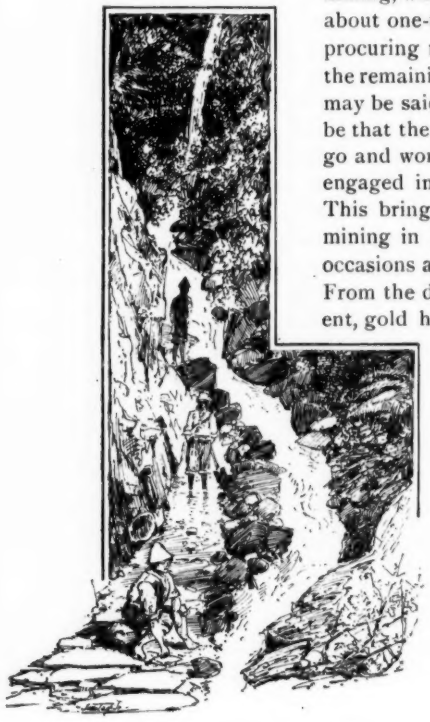
even beneficial effect of this plant in the long, hard journeys in the mountains, where food is difficult to obtain and more difficult still to transport.

The same confidence in their fellow men is seen in the *Cocales*, or coca-plantations, that is noticed with regard to the potato-fields. The plants when bearing are good-sized shrubs about as large as a very sturdy currant-bush, and they continue to produce for thirty or even fifty years. Every vestige of green is stripped from them three times each year, and yet the undiscouraged plants put forth a new growth. The leaves after being gathered are dried and packed into round bundles called *sestos*, covered with coarse cotton cloth.

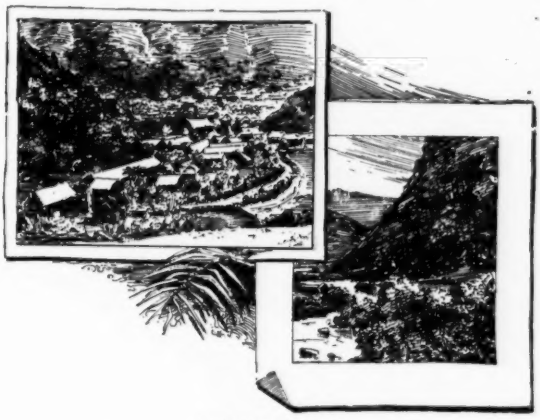
Coca is exported from Peru in great quantities to supply the cocaine of commerce, now so extensively used in medicine and dentistry.

In addition to these resources the Indians have their sheep and llamas, and at the proper time each year shear the wool, which the women spin by hand as they travel along the road and then weave into cloth for every article of clothing worn by the family. Thus a portion of each year is spent by the Indian in providing for the members of his household everything needed to make them comfortable according to the narrow requirements of their semi-civilized condition.

The bearing of this somewhat extended discussion of the habits and characteristics of these Indians upon the question of gold mining, will now become apparent, for only about one-third of the year is needed for procuring means of subsistence. During the remaining months the Indian of Sandia may be said to be a gold-digger. If it so be that the Governor issues a call he *must* go and work; otherwise he is likely to be engaged in mining on his own account. This brings us to the general subject of mining in Peru, especially in Sandia, and occasions a brief review of times far past. From the days of the Incas until the present, gold has been produced in Peru to a very large extent, although it is as a silver-mining region that this country is most commonly known. During the period of the Spanish conquest in 1532, Atahualpa, the last of the Incas, was seized by order of Pizarro and loaded with chains. To secure his release the Inca offered to fill with gold, as high as he could reach, a room twenty-two by seventeen feet. The Spaniards were amazed at this offer,



"BOOMING" ON THE MOUNTAIN SIDE.



A VILLAGE IN SANDIA.

and in fact had not patience to wait for so vast a quantity to be brought together, but seized and divided a portion of it, and finally by a breach of faith such as often characterized the dealings of the conquerors of the New World with the natives, put the unfortunate Inca to death. At about the same time report states that there was in Cuzco a gold chain long enough to encircle the entire plaza of the city. There is abundant evidence that a large percentage of this amazing supply of gold came from Sandia, and we still find old superstitions and old methods of working which have come down through the three hundred and fifty years which have elapsed since the last of the Incas fell a prey to the ruthless invader. Alike in Eastern and in Western lands, where the advance in civilization has not kept pace with the progress of the centuries, we find this same adherence to ancient methods of workmanship of all kinds. As were the fathers so are the children, and therefore a visit to Peru to-day is but the drawing aside of the curtain of the past. Sandia bears unmistakable evidence of the industry of the Incas. Old copper tools have been found in many places, and it is probable that many of the immense gravel banks of which we see remnants in the shape of thin combs and ridges, were subjects of Indian engineering. Such roads as the district can boast are of Indian origin, and just on the borders of the gold fields there are many circular stone huts still in perfect preservation which were formerly inhabited by that strange aboriginal race.

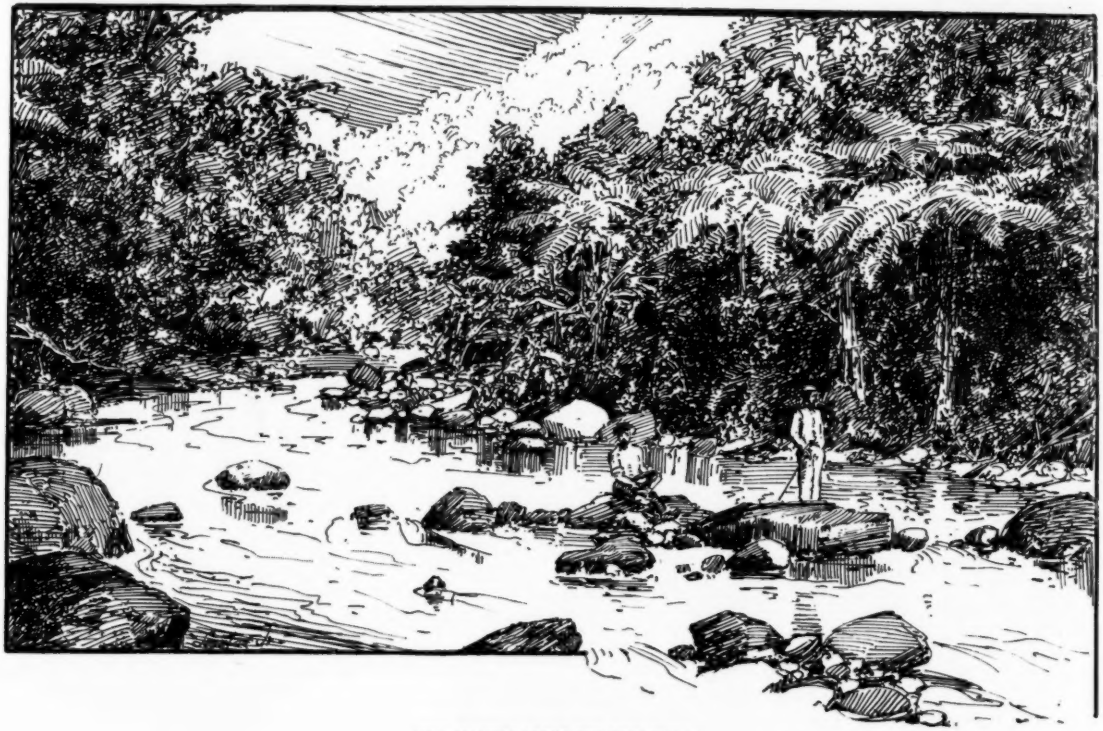
Garcilazo de la Vega, surnamed the Inca, was born in Cuzco, Peru, in 1530, his father being a Spaniard and his mother a native princess. His history of Peru, published in 1609, is esteemed for its fidelity and accuracy, and contains accounts of the gold mining in the province of Aymaraes in the time of the Incas, in which are descriptions of methods the same as those used to-day. It seems evident that the Spaniards must have wrung from the Incas the secrets regarding their best mines, and have immediately proceeded to work them, and that these methods continued in vogue throughout the Spanish occupancy and through the Portuguese ascendancy, when Spain and Portugal were united, from 1580 to 1640, and that they have been continued ever since by the natives, with energy, economy, and astonishing success. The aristocracy among the Incas controlled thousands of the inferior Indians and sent them to work in the gold fields, just as the Governor now sends them, without supplying one article of food or raiment or paying them one cent of wages. Owners of mines in the time of the Spaniards petitioned the Virrey for *mitas* or quotas of Indians, numbering into the thousands; in 1615 Quiñones Frisancho received 6000 Indians from the Government to work in Aporoma. Under that system of unpaid labor gravel banks 300 feet high have been worked, although they contained only four to six cents worth of gold per cubic yard. Some, of course, have been much richer than this, but millions of tons have been removed, and an infinitesimally small amount of gold extracted by a system of "booming" much less perfect than our California hydraulic system. The method consists simply in letting loose from a reservoir a large volume of water which, rushing against the banks, disintegrates them. The gold is then caught, as it has been for four hundred years and as it is to-day in California, in interstices between rocks which line the bottom of the canals. The Incas used the cuts in the rocks or ground sluices, where to-day we use plank troughs or sluices. In either case, to clean

NO LONGER PROFITABLE.

AT WORK WITH THE BATEA, OR GOLD PAN.

up, the rock pavement is lifted and the concentrated dirt is still further washed, and finally the gold is cleaned in a *batea* or wooden pan. This *batea* is conical in shape. The operator by a few dexterous motions makes the gold settle to the bottom, when most of the superincumbent mass can be quickly removed by a perfect mechanical rotary motion. This seems superior to our pan, which must be carefully handled from first to last, the dirt being removed little by little lest gold should be lost. Moreover, it would puzzle a Californian to wash twenty pans of gravel per hour containing float gold, yet this is the ordinary quota of Indians earning forty-five cents per day.

To work smaller amounts of gravel the Indians employ what is known as an *ingenio*, consisting simply of small canals constructed of flat stones, into which all the gravel is washed down a narrow channel, and made to pass first over a flat paving stone, then over transverse troughs filled with fern roots,—a good riffle,—and finally over a rough woollen material like our blanket sluices. Could anything be better or more ingenious? Quicksilver is used when necessary, but most of the gold is collected without it. To catch the gold brought down the river each year in the time of freshets, the Indians have an ingenious method. They pave the banks of the river between high and low water with flat stones, leaving a slight step or fall on the down-stream side, and the gold is caught in the little cavities under these steps. Once a year, in the dry season, these stones are taken up and the concentrates washed.



GOLD WASHING AMONG THE TREE-FERNS.

No one watches these places, yet it is unheard of for any but the owner to clean up the gold. Some of these are owned by a community, and many Indians will come together for the annual "clean-up." They collect the dirt and then measure it into piles of equal size, each one of which must always be marked with a cross. Instead of keeping in partnership until the gold is collected and then dividing it or the proceeds of the sale, the Indians draw lots for the piles of dirt, the result naturally being that the division of the gold is very unequal. Garcilazo de la Vega says that the Indians of his day lined similar canals with turf, over which was a covering of a root called *Ichu*. Leading into the main channel were branches very much like the ground sluices of modern mining. In the Department of the Amazons on the river Marañon, report has it that the Indians use an old dug-out canoe, the bottom of

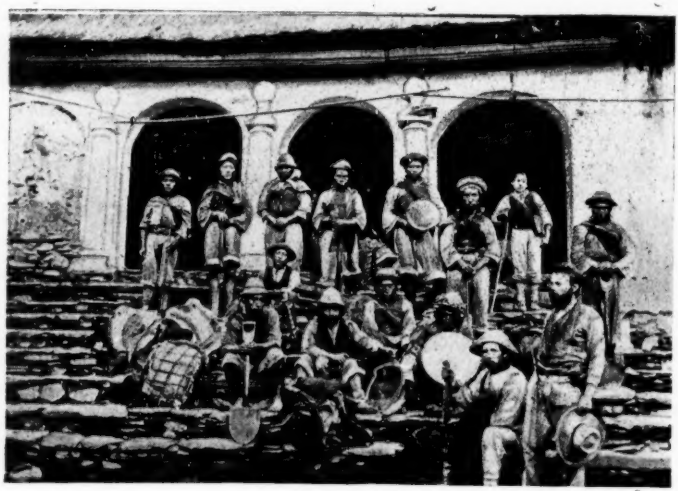
A NOVEL USE FOR A CANOE.

which is fluted with transverse grooves. This is set at a slight inclination, and a gentle stream of water is allowed to run through it, the canoe meanwhile being rocked to and fro. The gold is afterwards cleaned out from the riffle grooves and bow of the canoe, much as in our long rocker.

It is curious to notice how, not only the methods of working, but also the popular traditions and superstitions have come down through many generations. The Indians were obliged to pay their taxes to the great Inca dynasty in gold, for which purpose they would extract an especial portion. If it proved that they had secured a surplus, the balance was carefully taken back to the river whence it had been washed and thrown into the waters. To-day the Indians will never clean up the last grain of gold, always leaving as it were a little for *seed*.

In the Department of Apurimac, where the chacupa or turf is used in the bottoms of the canals for catching the gold, this is always dried before the gold is washed from it, the purpose being according to the statement of the Indians to ripen the gold. Modern scientists who claim that gold has power to germinate and increase in the bowels of the earth would appear not to have advanced beyond the conceptions of the aborigines.

The common superstition regarding Friday as an unlucky day



OUR WORKMEN ON OUR RETURN TO SANDIA.

exists in Peru, as elsewhere, but still more is Tuesday regarded as a day of evil omen, and no expedition will be started on that day.

The present and future outlook for gold mining in Peru is a subject requiring much consideration. There is no doubt that gold is very generally disseminated throughout Sandia, not only in the high gravel banks already mentioned in this article, but in pay streaks on or near the bed-rock in the river-beds and in quartz veins. It is distributed from the limit of perpetual snow down to the banks of the Huari-Huari at 3000 feet above the sea. In the Huma Apacheta where gravel has long been worked, the banks are lined with tropical vegetation, beautiful tree-ferns, and other plants of rare beauty. There the author of this article observed the valuable

Eucalyptus globulus, popularly known as the Australian Blue Gum, which although it has been largely transplanted into Peru from Australia, appears to be among its indigenous growth.

The ancient methods of mining seem to have been admirable, only lacking the one important principle of maintaining a constant stream of water from a pipe under a great head against the gravel bank, as is done is the hydraulic methods of to-day. There is only one place in Peru where the California hydraulic process has been introduced, namely at Poto, on the property of Señor Peño at an elevation of over 16,000 feet, whence a large product has been expected this year.

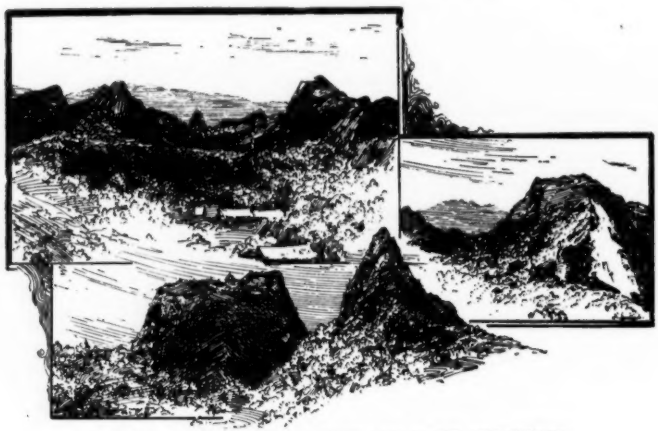
We fully concede the advantages and merits of hydraulicking where the essential conditions of amount of gravel, water under sufficient head, and room for dumping tailings are to be found, but for working smaller properties energetically, cheaply and successfully, it must be granted that the results of the ancient customs justify their long continuance. When it is remembered that the men worked for nothing and boarded themselves, is it any wonder that their masters grew rich? We often see attempts to sustain the position that well-paid labor can compete with the *peon* class, but in Sandia we see how easily possible it was for hard task-masters like the Egyptians of Scripture history to impose grievous burdens without even supplying the straw for the bricks. They were content to have a small result represent a vast amount of labor. Take as an illustration the minimum yield of only five cents to the cubic yard. This would be washed in a hundred bateas or pans, and it is quite possible that there would be only from one to thirty-five minute specks, or "colors," of gold in every pan or in other words the whole yard would contain an amount of gold equal to one-twentieth of a gold dollar divided into three hundred or more specks—each one only averaging one six-thousandth of a gold dollar and yet this infinitesimal quantity can be detected and weighed in examinations or saved in actual working.

Like their prototypes of old, there came a time when these unpaid hordes of laborers rose against their masters. Long after the Spanish had exterminated the nobility of the Incas, the lower class of Indians asserted themselves and drove the European conqueror from his gold fields. The last rising of this kind was in 1814, when the Spaniards were judged and executed in Phara. This well-nigh put a stop to mining by the whites until 1849, when the world had become aroused by the wonderful discoveries of gold in

California. At about the same time, men searching for Cascarilla, or Peruvian bark, discovered rich gold washings in and near Challuma, the result being that some very rich nuggets and a large quantity of gold were taken out.

The Aporoma hills in the Department of Puno bear their history of the past, and offer possibilites for the future.

San Bernardino shows high gravel banks, first washed centuries ago, the mere spectral image of their former immensity, remaining as high, narrow, fantastically-serrated ridges of gravel, making a picturesque and almost grotesque feature in the landscape. Cancarachi is another hill in the same neighborhood, and Humpire lifts its majestic head nearly four hundred feet above the surrounding country



COMBS AND RIDGES OF THE MOUNTAINS LEFT BY THE GOLD-DIGGERS.

and defies the intrepid engineer to bring water at a high enough level to reduce its mighty mass. From the Puli-Puli River much gold has been washed, even at the expense of the removal of heavy boulders which obstruct the shallow stream.

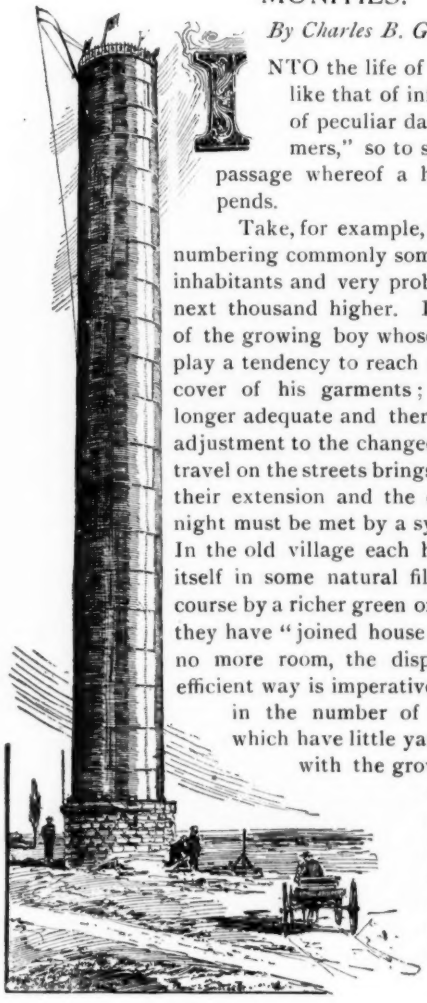
And now it remains for modern engineers to decide and to prove whether there yet remain concealed in these hills and streams still greater stores of wealth to contribute to the needs of our modern civilization ; whether the combined efforts of advanced and applied science, skill in prospecting, improved machinery and intelligent labor shall have their reward in success, or whether the gold-fields of Peru shall go down into the coming centuries known

scarcely more distinctly than the treasures called forth by the magic of Aladdin's lamp or the genii of the Arabian Nights.

It would certainly seem that the outlook would justify further exploration and experiments, and with the development of the country, and especially with improvements in roads, the twentieth century may see a revival of the glory of this long-neglected land.

THE SECOND SUMMERS OF VILLAGE COMMUNITIES.

By Charles B. Going, Ph. B.



THE STAND PIPE.

INTO the life of organized communities, like that of infants, there come periods of peculiar danger; its "second summers," so to speak, on the successful passage whereof a healthy continuance depends.

Take, for example, the incorporated village numbering commonly some two or three thousand inhabitants and very probably pushing on to the next thousand higher. It has reached the stage of the growing boy whose wrists and ankles display a tendency to reach out beyond the friendly cover of his garments; old provisions are no longer adequate and there is crying need for an adjustment to the changed conditions. Increased travel on the streets brings demand for pavements; their extension and the enforced use of them at night must be met by a system of public lighting. In the old village each house-drain perhaps lost itself in some natural filter bed, or betrayed its course by a richer green on the lawn; but now that they have "joined house to house" until there is no more room, the disposal of waste in some efficient way is imperative; and with the increase in the number of small houses especially, which have little yard room or roof-area, and with the growing danger of pollution of wells by the enlarging population, the need of a pure and reliable water supply forces itself day after day upon the householder and "will not down."

With one exception this question of water sup-

ply is beyond all cavil the most important which will arise, for the reason that it affects not only enjoyment but health; not only comfort of living, but life itself—with one exception, note, and that a most important one, sewerage! Yet it may be that this stands not in the lead in importance but side by side with it. It is true many sanitarians hold that until an efficient means of carrying off waste is provided the introduction of a free supply of water is attended with actual danger; but the question hardly admits of debate whether the risk attending the introduction of a sewerage system in the absence of an adequate water supply would not be even greater than this.

A PRETTY SAFE SOURCE.

The one situation entails possibilities of over-full vaults and surcharged drains; but these evils make themselves so obvious as to bring their own correction; and all authorities admit that waste matters, exposed as those would be to light and air, though still offensive are by the very fact of this exposure robbed of half their dangerous properties. The other condition, sewers without abundant water or with an uncertain supply for flushing and cleansing them, has attendant possibilities of stagnation and fermentation away from the sun and atmosphere (the most dangerous possible conditions), and of unfilled or seldom refilled traps through which the deadly sewer gas may find its way into places where it should not; danger most menacing to health and life—all the more so

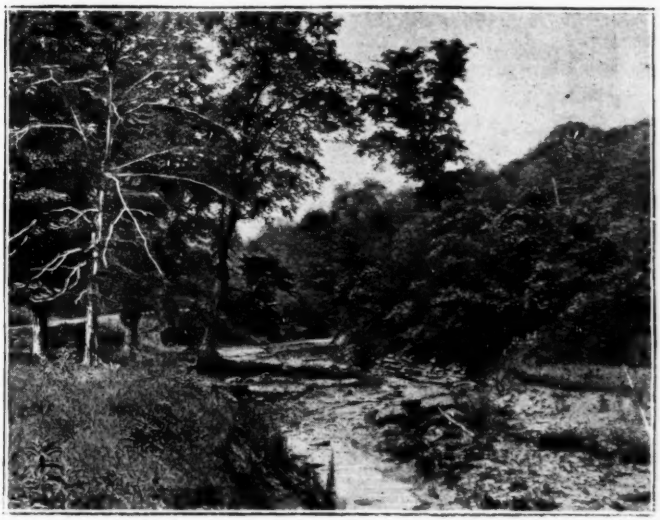
from their unobtrusive nature—and demanding the most efficient protective measures.

The ideal type of course is one in which both the arterial and the venous system are in perfect existence and operation. The ideal village will provide when the proper stage of its growth is reached, water supply and sewerage systems synchronously, neutralizing the dangers of each by the benefits of the other, and incidentally passing over in the shortest season possible the necessary period of disordered and blockaded streets.

In anything except the ideal village however this point will not be reached without internal throes. The owner of the good old-fashioned well will extol the salubrity of its waters and bring forth its sparkle and pleasant taste in evidence thereof; all suggestion of pollution he will treat with contemptuous scorn, and possibly will decline indignantly to convince himself (by salting his vault heavily and noting the taste in the well water) on the ground that he is "not going to spoil his well." This Douglas in his hall, entrenching himself among his numerous cisterns, will oppose any scheme involving an assessment on his large frontage or an increase in the tax levy. The conservative man, opposed to the growth of the village which he expects to follow modern improvements; the suspicious individual, looking for the great American "job" in every project, or timorous of granting a franchise to anybody for anything; and the crank, opposed to all things in general; these all will be in arms when water-works are proposed.

But on the other hand, public health, domestic economy, the demand of factory interests in a manufacturing community, or of landscape gardening in a place of suburban residence; the need of fire protection in any case—all these factors working through fit exponents will contribute to create that public opinion which advances public enterprise.

It is safe to say that the city-fathers in the majority of cases, to make use of another's apt expression, will "walk the floor" with their charge many nights before its internal uneasiness is quieted and an orderly conclusion is reached. Probably the first great decision to be made will be between a public enterprise and a franchise to some corporation. For small communities especially the latter plan has certainly many advantages. All but the last two classes of objectors before mentioned should be appeased thereby; while the quality of water and the source from which it is furnished, as well as the rate to consumers, must be determined or



JULY—VERY LITTLE WATER.

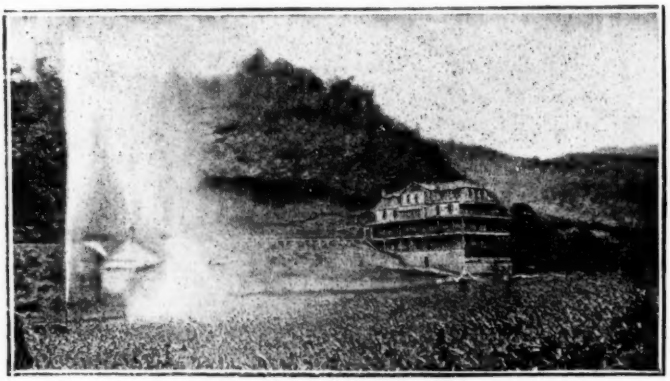
approved by the council after the most careful consideration and aided by the best advice. Then the uncertainties and difficulties of search and supply are largely removed from public charge; there is no "first-cost" whatever to the village and hence no increase of its debt; and the water-rate, properly apportioned to consumption, places the burden of expense accurately upon those who derive the benefits from the improvement.

But if the village constructs and operates its own water-works, a burden is thrown upon the authorities very much heavier than it would be in large corporations; for the proportionate expense may be greater and the individual criticism to which they are subject more keenly felt than in the comparatively impersonal governing bodies of a city.

It may be taken for granted at once that no engineering work of any magnitude will be feasible, and in the great majority of cases this will exclude at the outset any plan for the construction of artificial reservoirs; for not only will the probable great cost of any such schemes in mere construction and preparation, effectually bar its adoption, but also the difficulties of acquiring and exercising proper sanitary control of a sufficient drainage basin

will be beyond the power of limited capital and authority to surmount.

In certain situations it may of course be feasible, by the erection of a short dam, to complete the enclosure of a relatively large reservoir basin ; and as this is especially likely to occur in a mountainous district, there may easily exist as attendant conditions very cheap land, rendering possible the purchase of the required acreage at a small expense, and such conditions of topography and soil as shall render highly improbable any extensive settlement upon the territory whose drainage feeds the basin enclosed. Indeed a natural pond of pure water may be found at such elevation as will give the head necessary for high service or fire pressure, and at a distance so reasonable that the laying of a pipe-line



A GOOD HEAD.

will be economically advisable. In such cases the choice of the proper course is promptly determined ; for not only will the original outlay be small, but the subsequent care and expense of maintenance will be at a minimum and the water will be pure and soft and protected by natural conditions from future pollution.

But the instances of villages so fortunately situated are relatively few. Throughout the great central portion of our country especially, not only are the requisite physical features wanting, but an evenly distributed and closely settled population contribute both to enhance enormously the value of land and to increase the danger of the pollution of surface waters by agricultural and house waste.

To a municipality lying therein, it is fairly safe to say the problem of maintaining purity in stored waters will not be the first to present itself ; rather will attention be directed to some river or smaller water-course as the most available source of supply.

And under the best conditions none could be more desirable or satisfactory. The waters of streams, even in a limestone country, are very frequently softer than those of shallow wells in the same district ; their very motion imparts a certain life and sparkle and preserves that purity so hard to maintain in quiet bodies.

The question will concern quality of the water, reliability in the amount of supply, and location of the works.

First and foremost, as to quality,—the most vital consideration

CONNECTING A GROUP OF WELLS.

pertaining to the matter, and one demanding the most exhaustive consideration ! No doubt must be left unsolved, no chances accepted. It is not enough that the water be clear or sparkling or palatable. Over and over again these qualities have been found coexistent with the most dangerous pollution, and even in many cases derived from the very agencies causing such pollution. The point must be determined by the aid of the best advice guided by full knowledge, not only of the character of the water at the proposed place of withdrawal, but also of the kind of territory through which the stream flows and its relation thereto as a drainage medium.

The swift clear stream, gathered from mountain slopes and rocky hill-sides, is little likely to be contaminated, and from such a stream moreover, on account of the rapid fall, the water may easily be withdrawn from a high level at a short distance only from the village. When, however, the proposed source of supply is a lowland water-course, winding through highly cultivated fields and amid a relatively dense population, it is not only subject to more or less pollution throughout its entire extent, but may very probably be utilized by some communities as a sewer, to its great detriment as a source of water supply at lower points. Yet, such is the self-purifying power of streams that not even this usage would be necessarily condemnatory. By sedimentation in long quiet reaches; by filtration through gravel-bars; by the influence of water-plants and of atmospheric oxygen, the deleterious principles may in a sufficient length of flow be removed with practical completeness. It is an intricate question into which the relative volumes of the pure and the impure, the speed of the current and the nature of the bed, all enter as factors. The Hudson was declared an entirely safe source of supply at Albany although receiving all the sewage of Troy only eight miles above, while in England such rivers as the Severn, the Tees and the Wear were formally condemned for similar use after thorough examination, at points from thirteen to seventeen miles below the place of contamination.

With any stream of this character the necessity of pumping will of course be introduced. This may be over a "stand-pipe" or into a small elevated distributing reservoir to secure the needed pressure in supply pipes; or by the Holly system the pumps may force directly into service mains, with possibly an arrangement of relief valves opening upon any excess of pressure and discharging the surplus water into a cistern, where it may serve as a reserve for use in case of fire.

But while present purity and safety from future pollution within reasonable limits are the great prerequisites, without which no offered source however abundant can be for a moment considered, yet an intermission or remission of supply once established is a source of so great discomfort and so grave danger, that assurance of ample water at all seasons will be sought probably even before the sanitary conditions are examined.

Many streams, especially in districts where there is much timber and undrained land, have such stability of volume that they

may be depended upon with almost absolute confidence to maintain, summer and winter, a flow sufficient for the purpose under discussion; but through most of the central and western States the characteristic displayed by the rivers is versatility rather than constancy.

February may find them occupying their valleys from hill to hill and utterly overwhelming both water-works and water-users with such excess of that which they had sought as will convert the blessing into a curse: July, again, may look into a dry stony bed through which hardly even a dispirited thread trickles from pool to pool. This low stage of water, even when not breaking the continuous current, may so concentrate the impurities in a stream as to render unfit for drinking purposes waters at other times quite safe.

A village limited to a stream subject to such drying-up, or unable from geographical situation or other cause to secure an adequate and satisfactory supply of atmospheric or surface waters, may be forced to seek in the only remaining direction the "waters under the earth," if it is to be supplied at all. Well-boring is offered as the panacea of all ills; the triumphant answer to hitherto unanswered conundrums; the power which is to bring forth for a thirsty people water from the smitten rock and cause streams to flow in the desert.

In annually increasing numbers, especially through the central and western States, villages are seeking by this means to secure the requisite conditions—purity and abundance in supply, small cost of establishing the works, and inexpensive subsequent maintenance.

Wherever topographical and geologic conditions are suitable, no source is more to be commended than this, for either small or large supplies. Frankland, in his Wakefield water-bill evidence, says that "of all sources of water-supply, springs and deep wells are to be preferred." Voelcker considers "river-water at the best * * * a poor water, and not to be compared with spring-water, which is always refreshing and is a clear and unquestionable water." The deep well is merely an artificial spring, located, within certain limits, at will; in other words, it is an outlet for subterranean reservoirs which derive their supply from the percolation of rain waters through the surface strata at more or less remote locations. There is *prima facie* probability that rain-water collected from a large area of open and sparsely settled country, will be but little

contaminated; and in its deep percolation through porous strata it undergoes such a process of natural filtration as has been aptly said to render water pure without making it flat, while artificial filtration renders flat without making pure.

Such waters as this, collected perhaps on high pure mountain slopes, carried through perfect filters to an underground reservoir which needs not to be purchased, and is subject neither to taxation nor ground-rent; protected from contamination, not by sanitary legislation nor police supervision, but by overlying strata impervious and unbroken—such waters as this the artesian well is supposed to and in many cases does furnish.

It is seemingly a particularly suitable source for a small town; for while difficulty is sometimes experienced in obtaining by this plan a large supply, on account of the fact that each additional well put down may rob those already furnishing and itself yield a smaller flow than its predecessors, yet it may be very easy to secure from one good well a supply of one million gallons *per diem*,—ample even for fire purposes for a village of the size we have been considering.

Safety requires in any system of surface storage the constant maintenance of large surplus capacity, both to provide for possible growth of the town and for temporary failure of supply from drought, an emergency which may not occur once in many years. The steady and reliable flow of an artesian well removes all danger of the latter contingency; and if an increased amount becomes necessary, the sinking of a second well will probably add enough to afford adequate relief under ordinary conditions. If the place should experience such a "boom" as to entirely outgrow the provisions made for it and be compelled to look abroad for a system of impounding the water of some natural water-shed, which is in general the source of the most generous supply of a fairly pure water, little difficulty could occur in finding in some private corporation or manufacturing enterprise a ready purchaser for the discarded water-works.

But, says the adage, "All that glitters is not gold." We do not make an artesian well simply by sinking a pipe and pumping the water which flows into it from the bottom; neither must a well of this description assume to itself all the approval given to the artesian system. It is true that the iron tube of a deep well may serve a beneficent purpose in excluding the immediate surface soil drainage; indeed, it may be said generally that the burden of

proof as to purity which is upon surface waters, is on the other side with deep wells. And yet against a class of them which is gaining wide popularity in some sections, a case might all too easily be made. Such are those which Professor Orton names "drift-wells,"—that is, wells sunk in deep alluvial or glacial beds filling many of the valleys in the interior of the country.

In most of these sand and gravel deposits, immediately above the solid impervious limestone strata which underlie, is found an abundant supply of clear, bright, but somewhat hard water. The ease with which this reservoir may be tapped, the glamour cast over an unseen subterranean source, and more especially, the careful fostering influence of the professional well-sinkers, have brought these drift waters into dangerous prominence for town supply.

The true artesian is properly a flowing well, bursting forth only when the impervious covering stratum of rock is pierced, and mounting rapidly in the pipe to the level of its distant upland source. These pseudo-artesians, on the other hand, frequently find the water only a few feet or few yards from the surface ; and at that same level it remains when the well is finished.

When the deep well pump is set to work, a circulating action begins, in which the surface waters are drawn down outside the pipe, undergoing a certain filtration in the extremely porous sand and gravel beds, and are then taken up inside the pipe, and delivered to the consumers.

For fire protection, or for street and lawn sprinkling, such waters are open to no criticism whatever ; and being cheaply and easily obtained in abundant supply, water-works so furnished might be a profitable enterprise though devoted to no other uses than these; but for laundry and manufacturing uses the water is generally rather too hard, and for human consumption it must unfortunately be utterly condemned. Condemned, because that protection from surface contamination which constitutes the value of the true artesian is lacking, and every year of the town's existence and growth adds to the danger of fouling its supply ; condemned more especially because of the fancied security, arising from the misapplication to this plan of the praises bestowed upon a radically different, though superficially similar one, which may lead to a fatal relaxation of vigilance in inspecting the water.

No positive rule can be formulated as to the depth which would make a well safe ; the decision must be made by the aid of thorough study of local geology and topography. Chemistry can

detect at once the ear-marks of dangerous pollution in a drinking water, but the best guide to safety is knowledge of its life history.

Let it be borne in mind that at the present day no one connected with any enterprise concerning public health has any right to ignorance; and that the order of consideration in every such case is safety *first*—saving in expenditure afterward!

THE MECHANICAL DISPLAY AT THE WORLD'S FAIR.

By Edward Atkinson.

THE subsequent suggestions for the conduct of one department or division of the World's Fair were originally made in letters to gentlemen whom it was supposed might have an interest in the matter. These letters have been slightly changed and somewhat condensed in order to fit them for ENGINEERING.

I have watched with some interest the course of the discussion on the exhibition proposed for 1892. I have had a little experience in such matters, and have given some thought to the subject. I therefore venture to make some suggestions, leaving it to others to decide whether or not they are of any value, and whether or not they should be adopted.

It seems to me that the day has gone by for a great world's fair or bazaar in which all kinds of goods and wares may be displayed, largely for purposes of advertising them, without much system or method and without any distinctive purpose in the general scope or plan of the exhibition, except *to make a great show.* Any one who desires to study or observe such goods and wares can find a better exhibition in the shop windows than has ever yet been put together in a world's fair or bazaar. Such fairs are cumbrous, costly, tiresome, and unsatisfactory. The time was when they were novel, interesting, instructive, and useful. The diplomas are now as a rule of little or no value.

There was one conspicuous exception in the Centennial Exhibition of 1876 to the generally commonplace character or want of distinct purpose in the method of exhibiting. The Kansas and Colorado exhibit of natural products and resources laid the foundation of the progress of agriculture and mining in that section.

When I was called upon to advise how the exhibition at Atlanta should be laid out and directed, my first conception was to bring together everything that could be exhibited or made known in regard to cotton, not only in respect to the fibre, but in respect to the seed and the plant. Presently it became apparent to me that such an exhibition would tend more and more to the concentration

of Southern efforts upon cotton only, and would stand in the way of the diversity of industry, which that special section especially needed; I therefore conceived the plan of imitating the Kansas and Colorado exhibit, and advised the directors to interest the Southern railroads, the owners of land, and the owners of mining property, in bringing together that wonderful collection of timber, minerals and the products of the soil, which really formed the most important part of the so-called Cotton Exposition. I have not until very lately admitted, even to my own mind, the benefit which grew out of that conception of that specific exhibition. When such men as the Messrs. Inman and others assure me that the effect of that exhibition and the carrying out of that specific suggestion made the real starting point in the progress of the South in all the arts which are now gaining so rapidly, and made known to the Southerners themselves as a body the magnitude of their own resources, which had hardly been conceived even by the few, I can no longer resist the conclusion that mine was a happy thought and that I did contribute in considerable measure to the progress and prosperity of the Southern States. Of course, in the nature of the case, the progress would ultimately have been made, but the great and early start is dated from the Atlanta Exposition.

On the basis of this experience I venture, therefore, on some suggestions for the exhibition of 1892. If that exhibition is to be held, a very large sum of money will evidently be raised, and it will be a pity that any considerable part of the expenditure should be wasted upon a mere copy of the world's fairs, centennial exhibition, and others of that kind. On the other hand, a moderate amount of money rightly expended may produce very great effects upon the future progress and welfare of the whole country.

The motive of the exhibition in 1892 is that the year recalls the date of the discovery of America by Europeans 400 years ago. Ought not the motive of such an exhibition to be the *progress in human welfare in four hundred years, through the application of science and invention to the pursuits of peace?* Ought not such an exhibition to illustrate the interdependence of nations, the growth of commerce, and of modern industry—prophetic of the time when war shall be forbidden at the command of commerce? Four hundred years ago the invention of gunpowder had only begun to promote equality in the conditions of men; it had only begun to make the power of the serf equal to that of the seignior; it had only begun to do away with the dominion of privilege, and to establish

the dominion of human rights; it had only begun to alter the relations of men in the exchange of services from distribution according to *status* to distribution according to *contract*. The invention of printing had only begun to diffuse intelligence; it had only begun to make possible and to establish a system of common law; it had only begun to make known to the poor and feeble that He who created the world ruled all things well, and recognized no difference among men because of race, birth, condition, or color. The long struggle for equal rights, first taking the form of resistance to superstition, and of wars waged nominally on religious grounds, was soon converted into a system of war waged by nations in order that the so-called civilized nations of Europe might each on its own behalf dominate sections of the new world and control by force and by colonization the commerce of the continents or of parts of continents secured by war and conquest, for the sole benefit of the European countries each for itself, by whom this dominion had been gained.

It is only within the last century of the four, or only since the physiocrats of France first entered upon the study of the relation of men to each other, and since the publication of the "Wealth of Nations," by Adam Smith in 1776, that the true function of trade and commerce has begun to be conceived among civilized men. Even at the present time the continent of Europe, which, if we separate the uninhabited portions of Norway, Sweden, and Russia, is about equal in area to the area of the United States, omitting Alaska, is divided up into substantially nineteen separate empires or States, each cut off from the other by barriers to mutual service and by restrictions upon their traffic, at which barriers taxes are levied upon commerce; the avails of such taxes being more than expended in the support of armies and navies which, except for these barriers to mutual service, would not be required. Witness on the other hand, the growth and progress of this nation. The freedom from obstruction to mutual service among its citizens which was established in our organic law, in that provision of the Constitution which forbids any interference with commerce between the States, is without question the rule to which we owe more than to anything else, the preservation of the Union and the freedom from the blood tax, as well as the money tax of a standing army.

My ideas run away with me in trying to give my conception of what the exhibition of 1892 might be.

We may begin with the art of spinning and weaving. The

origin of these arts is prehistoric. From the earliest dawn of history woven fabrics have been in use. The linen in which the mummies of Egypt are wrapped is equal in the fineness of the thread and in the texture of the web to many of the examples of the finest work of the modern loom. The distaff is classic, some of the natives of northern Italy and of Greece could be brought to the exhibition who would spin linen thread with the distaff after the manner of Penelope. The loom and the weaver are pictured, as I have been informed, on the walls of Babylon and on the Pyramids. The hand loom worked by the native Egyptians in the same way and of identical type could be brought to the exhibition. Neither the inventor nor the date of the invention of the spinning-wheel is known. The spinning-wheel of the prehistoric type is worked to-day for clothing nine-tenths of the population of China; the wheel and the spinner, the loom and the weaver, could be brought together from there. The wheel and the loom of the same identical type are to-day in operation in the heart of the Southern mountains, working on cotton and wool, and in the western counties of Ireland working on Irish homespun. The representatives of these prehistoric arts could be brought from there and from many other points in Asia, Africa, South America, Australia and Polynesia, with examples of all their fabrics, ancient and modern.

Such an exhibition as the one proposed would undoubtedly lead to the establishment of a great and permanent textile museum and weaving school, equal or superior to that at Crefeld, in Rhenish Prussia, which was formerly open to Americans, but from which they are now excluded. Such schools have only lately been established even in England, although they have existed for a long time in Germany and France.

Within the same rail on the floor of the Atlanta Exposition were two hand-carders, two spinners with their wheels, and one weaver —five persons, who could make in a day of ten hours eight yards of narrow coarse cotton osnaburg. Within the same rail was the carding and spinning machinery of the Willimantic Thread Company and the looms which were sent there from Massachusetts, on which the cotton which was growing in the field in the morning, after it had been picked, ginned and prepared, was spun, woven, dyed and made into a dress suit which I wore at a reception the same evening. The difference in the capacity of the operatives who worked these modern machines as compared to the homespun art on the same fabric was one hundred to one, by actual computation.

The first step in the progress from the spinning-wheel of a single spindle to the spinning mule of 1200 spindles was the spinning-jenny of eight or ten spindles. Some of these spinning-jennies are still made use of, I believe, in Africa, to prepare the yarn for a hand-loom which is carried about in the hands of the natives, on which they weave the narrow strips of which their garments are made when they have been stitched together. The African spinners and weavers, with their machines, can be brought to the exhibition.

In South America, in Mexico, among the Indians of the far Northwest and in every part of the world are people of various tribes and races who clothe themselves in homespun and hand-woven fabrics, as our grandfathers and grandmothers did in New England only a century since.

It is easy to conceive of a department in the exhibition in which shall be built the cabin of the African, the cobble-stone dwelling of the Irish cotter, the model of the cottage of the English peasant, the dwelling of the Chinaman, the wigwam of the Indian, the log cabin of the Southern mountaineers, where each type of each race may conduct the art of spinning and weaving in their own way; while in the next compartment may be exhibited the finest examples of the most modern textile machinery; in this one section would be given the history of clothing from the fig-leaf to the type of the present day. Even the preparation of the different fibres may be brought into view. The seed of the cotton is cleaned from the fibre in China at the present time by the snapping of a bowstring; precisely as it was done in Georgia, giving the name of "bowed cotton" to the Georgia staple before Eli Whitney invented the cotton gin.

Again, while the art of weaving begins with the hand loom in making the fabrics of the coarsest kind, the art also ends with the hand-loom on which the finest silks of Lyons and the finest velvets of Rhenish Prussia are to-day woven; and from these points the typical weavers could be assembled with their simple looms on which they make those finest goods which are in themselves a work of art.

In the matter of printing textile fabrics, the art began by stamping figures of a coarse and rude kind by hand upon the cloth; and that same art is still carried on in the same way in China and in Japan, and could be brought before the eye in the exhibition; while the progress in the art of printing textile fabrics could

be witnessed in the next section as it is now carried on by the use of machines of the finest and highest types. But this art would end again in the bringing from France the block printers who still print by hand the finest examples of the French cretonnes.

This conception of the method of the proposed exhibition is wholly consistent with making the exhibition itself a medium for bringing into notice the finest examples of modern machinery and the finest types of modern fabrics. The only difficulty which might be experienced in carrying out this conception might be that too many makers of machinery and vendors of the fabrics of the finest types would apply for place. The personal factor and the element of individual profit may therefore be brought to bear in connection with this plan, as well as in any other way.

If it were too great an undertaking to bring together typical examples of the garments of the past as well as of the present, nevertheless, pictures may be gathered to hang upon the walls, artistic in their conception, typical of the art in the different countries in their execution, which would be object lessons in the history of the textile arts.

If we pass on from the textile out to the treatment of metal, taking iron as an example, we find that iron is still treated in Spain as it was when the Toledo blade became famous. It is treated in Africa in the crudest manner. In the heart of the southern mountains, iron and steel are still made directly from the ore in wayside furnaces heated with charcoal on what I believe are called "Catalan forges." How various or how widespread over the world are the different methods of treating the ore of iron, I am not informed, but all these primary methods could be brought with those who practice them into one section of the exhibition; and since the introduction of the most modern type of furnace worked by gas has been adopted, it has also become possible to set up small examples of the most modern form of producing iron and steel and working these metals into manifold shapes. The whole history of metallurgy as applied to iron can be brought before the eye; and here again the element of personal interest may be brought to bear on the part of those who desire to exhibit the most modern types of stoves, smelting furnaces, and the like.

Perhaps the most interesting and the most varied of the many arts which can be brought together into view would be the types of the tools and machines used by various races and nations in the conduct of agriculture. Herein again, the plough, as pictured upon

the walls of the Pyramids, could be brought from the fields of Egypt, with the fellaheen, who still make use of that prehistoric implement; and alongside could be placed the modern polished steel plough of which I have a record among my insurance papers that when accidentally placed outside a barn it concentrated the rays of the sun, and reflected them in such a way as to set the barn on fire. Herein, again, there would be a rush of competitors to exhibit the best types of the most modern agricultural tools and machines.

Again, the one art which is of all others prehistoric, is that of the potter. Would it not be possible to bring the potters from many lands into a single section with their primitive implements, placed alongside the most modern type of apparatus with their artists as well as their ovens?

Lastly, there is nothing like leather. How easy it would be to bring into the same section the worker in leather from different parts of the world; the cobbler from that part of this country which has not yet been penetrated by the railway, alongside the modern machines by which each visitor, having been measured on entering the section, may have a last prepared to fit his or her foot and a pair of finished boots made to measure ready to put on within the time that would be necessary to get even a superficial idea of the mechanism by which the work had been accomplished.

When all these and many other arts had thus been brought together, to be conducted under one great roof by representatives of many races and many nations, each according to his kind, dwelling in his accustomed way and conducting all the household arts as they are conducted at home, the Arab in his tent, the African in his hut, the Mexican Indian in his adobe house, the mountaineer of the South in his log cabin, the native of Japan in his dwelling of wood and paper, the Chinaman, the Aleut, the Alaskan, and all the rest—what could be more attractive or instructive? And lastly, what would pay better in a mere commercial sense?

In addition to these object lessons, the art of the painter, and even of the sculptor, may be invoked to decorate the walls; the art of the engineer and of the mill constructor may be called in to build the structures; while the services of the statistician, the economist, the ready writer and the engraver would be required to prepare the catalogue and to write the descriptions, so as to tell the whole story of what the eye could see in part.

This would be the main conception to be carried out, either in

the main building or in the main series of buildings. Auxiliary buildings may be added by States, in the manner previously indicated, in which examples of every crude material, together with maps and descriptions showing the resources of any section of the country, might be brought together. If, in addition to this, it was thought expedient to make preparation for a great fair or bazaar where goods could be exhibited and sold according to the will of the contributor, that purpose might also be provided for in the exact measure of the demand which would ensue for space or place. The conditions precedent to carry out this conception consist first, in finding the money which will be required to make the preparation, and, second, the men (especially the man) capable of laying out, executing, guiding, and directing the whole work.

HIGHWAYS AND NATIONAL PROSPERITY.

By Edward P. North, C. E.

HE interdependence between the possession of cheap and efficient means of transportation and the control of those manufacturing facilities which must create the wealth and happiness of all long settled communities, is not sufficiently recognized. The intent of Macaulay's brilliant sentence in honor of those inventions which "abridge distance" has been perverted to an apotheosis of our present methods and appliances by a school of original thinkers who apparently wish to insure the maximum amount of transportation in the exchange of the world's products. But the cost of transportation, when it does not destroy production, acts as a most energetic and voracious parasite on all industries; its cost in all instances being divided between the producer and consumer, whether the cost is incurred in the interchange of the merchandise of distant nations or in distributing local productions.

Where the exactions of the carrier for his services in assembling the crude materials for manufacture have been or have become high in relation to the charges of other localities, manufacturing has either failed to develop, or once developed has dwindled into at least comparative insignificance, and the prices of raw materials and the product finished for consumption have become more widely separated, while the decrease in the rewards of productive labor has borne an irregular relation to the increased cost of transportation. On the other hand, the nations possessing appliances of transportation which were superior in efficiency or economy to those of their rivals, or, in other words, those that had the best highways, were, during the time of such possession, the richest and most powerful and also the manufacturers for the world.

The great arterial roads of the Roman empire, leading to the capitol (to slightly paraphrase a report by a Committee of the British Parliament on the steamer lines they were then establishing), "had for the object which led to the formation of these roads

and the large expenditures involved, the control of rapid, frequent, and punctual communication with those distant parts which fed the main arteries of Roman commerce, and with the most important of their foreign possessions; promoting the commerce and wealth of the country in time of peace, and assisting in its defense"; for the Roman armies were not supported by looting the huts of barbarians, nor was the wealth of the Imperial City accumulated from direct imposts on conquered provinces. The Roman roads, with the control of the seas, made Rome the great manufacturing centre of the world, and her armies were supported by the toil of her artisans, not by plunder; the provinces contributing to her wealth by the exchange of raw products for the manufactures of the capital city of the Empire. She fell through the combined influences of slave labor and the free distribution of African wheat, which eliminated the local agricultural population and reduced the Campagna to a wilderness.

All have noticed in Schiller's "History of the Revolt of the Netherlands," that Spain, with the wealth of the newly discovered Americas at her disposal, emerged from the contest beaten and impoverished; while as to Holland, Philip "himself furnished the rebels with the means of defraying the expenses of their own defense; for the very war which was to ruin them increased the sale of their goods." It was through her factories that she accomplished freedom and wealth. But Schiller did not notice that Spain, depending on pack-trains, could not compete in manufactures against the Netherlands, which had the cheap transportation afforded by its many canals, streams, and the shores of the Zuyder Zee.

In England, the Romans, besides building their roads, constructed several canals, one of which, the Fosdyke, connecting the Wash and Humber, is still in use. But from their departure until the fifteenth century there is no notice of any attempts to improve even her larger rivers, and the first engineer of record is Vermuyden, brought from Holland by Charles I. in 1626. From that time until 1756 some eighty local acts were passed, mostly for the improvement of rivers. Between 1758 and 1772, Brindey constructed 523 miles of canal, and his first great work, the splendid aqueduct over the Mersey and Irwell Navigation, which he was so nervous about that he went to bed when water was first let into it, will stand until it is taken down to accommodate the Manchester ship canal which has swallowed the more modest undertaking of the Duke of Bridgewater.

At the commencement of this century England had some 1100 miles of navigable river courses and about 1900 miles of canal, and in 1832 she virtually stopped canal building for over 50 years, to take up railroad building, with 3465 miles of canal and river navigation, or a mile of navigation for between 14 and 15 square miles of territory. There were also at that time 596 miles of canal in Scotland, Wales and Ireland. At the present time we have 1070 miles of canalized rivers, 194 miles of canal forming part of a river or maritime navigation, and 2099 miles of ordinary canal, or 3348 miles in all, besides many miles of open river and lake navigation. The construction of these canals almost immediately reduced the cost of freight to one-third and in some instances to one-fourth of the cost by pack horses, for Telford and Macadam, who have given their names to the two systems of road building, did not commence their great work of road improvements, the one until 1804, and the other until 1815, and until their improvements pack horses carried most of the freight transported by land in England.

Though ascribing cheapness to transportation charges in England may now excite a smile, England undoubtedly had the best and cheapest system of transportation of any country during the wars with Napoleon, a relative cheapness which made her the great manufacturing country and enabled her to add to her wealth while subsidizing the armies of her allies, as the gold she paid out came back to be exchanged for manufactured products.

In the meantime the improvement of her common roads had proceeded at such a rate that, as stated in Church's Life of Ericsson, 20,000 miles of turnpike, or more than the present railway mileage of the United Kingdom, had been constructed in England previous to 1826, and £2,200,000 had been expended upon them to increase the possibilities of land carriage. These roads were so good and well coached that a rate of seventeen miles an hour was made on one short stage between Cheltenham and Tewksbury, and while such speeds were only for the very rich, the splendid surface they imply contributed to the welfare of the poorest in the low cost of freight haulage.

This improvement of highways has been so continued in that country that by 1868 it was estimated by Mr. Vignoles there were 160,000 miles of good carriageable roads in the United Kingdom, or a mile and a third to every square mile of territory. England was also the first to adopt railroads. By 1857 she had half of her

present mileage, whereas it was not until twenty years after that we had built half our mileage, and up to nearly 1870 freights on all of her railways were undoubtedly cheaper than on American roads, and through these superior advantages in transportation she held the unchallenged primacy in manufacturing.

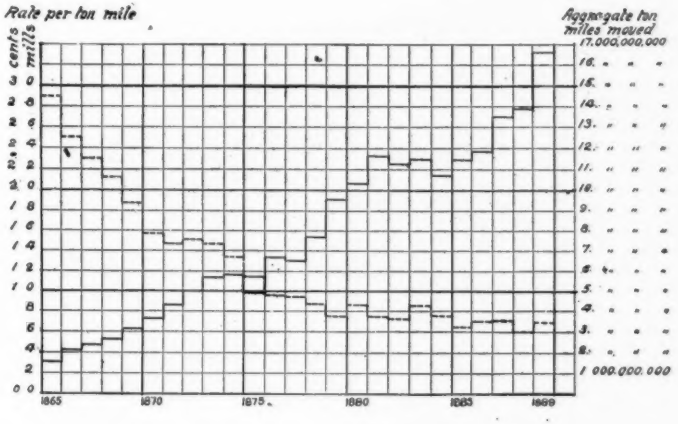
But, as testified before a Parliamentary commission in 1883, freight rates had remained virtually unchanged in England for thirty years as against a probable fall in this country to one-quarter of the rates charged in 1865. So that, according to Mr. J. S. Jeans*: "If the assumed English average were now charged on the American railroads, the income of the latter on the freight carried in 1884 would have been 200 millions sterling more than it really was!" But our railroad managers have not been allowed to rest; since that time the number of tons multiplied by the distance they were transported, or the ton mileage of our railroads has, according to Poor's Railroad Manual, increased 53.4 per cent., while the rate collected has fallen from an average of 1.124 cents per ton mile to 0.976 or a fall of 13.1 per cent. If the eminent "Member of the Council of the British Statistical Society" quoted, was correct in his assertion as to the relative cost of service in the two countries in 1884, the charges on the freight transported on our railroads in 1889 were fully thirteen hundred million dollars less than the same service would have cost on the railways of Great Britain and Ireland. It is this saving in internal freight charges that has enabled us to pay foreigners some 80 per cent. of the cost of our oversea freights without bankruptcy.

In Great Britain no returns are made by the railway companies to the Government or to the public, showing the distance freight is hauled or the average charges on the same, and authorities differ as to these charges; the lowest estimate noticed was $1\frac{1}{8}$ pence per ton mile, or $2\frac{1}{4}$ cents, and many claim 2 pence, or 4 cents, as a more likely average, but whatever these charges may be, they have remained substantially unchanged for nearly forty years, while the freight rates of other manufacturing countries have been decreasing, and from having the cheapest transportation the British "trader" now pays a higher ton-mile rate for assembling his materials and getting the product to market than the manufacturer of any other country.

In this country the editors of Poor's Railroad Manual have tabulated the returns of the aggregate tonnage moved; the aggre-

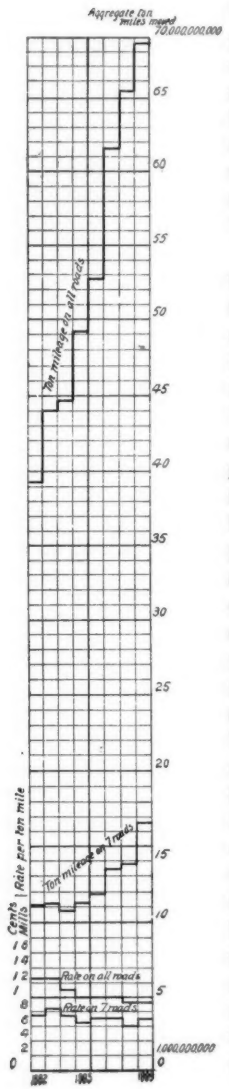
* "Railway Problems," London, 1887, p. 320.

gate ton mileage, and the average charge per ton mile on the Pennsylvania; Pittsburgh, Fort Wayne and Chicago; New York Central; Lake Shore; Michigan Central; Boston and Albany, and Lake Erie and Western roads, for the past twenty-five years, and the ton mileage and average charges per ton are shown in the accompanying diagram. The rates charged on the seven roads are shown by the dotted line and the ton miles moved by the full line. The chart shows that for 1865 the ton mileage was, in round numbers, 1650 million, and the rate charged for each ton transported a mile was 2.9 cents. In 1889 the ton mileage had increased to nearly 16,684 million, while the rate was seven mills



per ton mile. And if the rate charged on these seven roads twenty-five years ago had been charged on the traffic of 1889 the people served by them would have paid over 576 million dollars more for the service than they did.

From 1882 Poor's Manual has given the above figures for all the roads of the country; from which the accompanying diagram, on a reduced scale, has been constructed, with the record of the seven roads added as a matter of comparison. This shows that the ton mileage of the United States has increased during eight years from 39,302 million to 68,604 million ton miles, while the rate charged has concurrently decreased from 1.236 cents to 0.976 The savings to the community consequent on these reductions in



freight rates have been divided, in some proportion, between producers and consumers, resulting in higher prices for raw produce and lower costs to consumers: they have been directly helpful to nearly all interests in this country except those of Eastern farmers, who have found their incomes seriously curtailed by the cheap transportation offered to Western farm produce.

It was probably somewhat before 1870 that the average charge for transporting a ton of freight on all the railroads of this country fell below the rates accepted on English roads, and it is noticeable that in 1880 we were ascertained to have passed the United Kingdom in the value and volume of our manufactured products and in the aggregate of estimated wealth, although we have few good common roads, and are still greatly behind that country in length of railroads per unit of area. But in spite of these disadvantages our advance through the past decade, which is so greatly due to the decrease in the cost of transportation, has probably been at such a rate, that by comparison, England will appear to have been anchored. We, however, hold this advantage by a precarious tenure. If England should enlarge her system of canals and reduce her freight rates, which have for some time been from two and a half to three times as high as ours, to a basis commensurate with her lower wages, adopting American rolling stock at the same time, she would be able to leave us badly behind in the race for supremacy, through the smaller area to be served per mile of railroad or canal: through her magnificent system of common roads, and through the control she has obtained of ocean carriage.

At present our greatest want, in common

with that of more railroads in the South and in the mineral bearing regions of the West, is better country roads. There has, in this country, been a phenomenal cheapening in long haul transportation, but it is doubtful if we have as many miles of good wagon roads today as there were forty years ago, and the cost of wagon transportation is undoubtedly greater now than then. This cost, which is excessive, falls with the greatest weight in general on the scattered producers and consumers of crude materials; on those persons and commodities which are the least able to bear the charge. It falls with greater weight on farmers than on any other class, who producing in excess of the country's requirements, in the words of the old saw, "have to go to mill and have to pay the toll," that is, the cost of transportation is taken from their net receipts. Any improvement of their roads which would enable them to market their produce in full loads and at times when they cannot work in their fields, would make a great addition to their net earnings; an addition the aggregate of which would approximate in value to the saving to this country consequent on the reductions in railroad freights.

The necessity for better common roads is admitted by all, but as yet no practicable method of overcoming the greatest difficulty presenting itself seems to have been proposed. This difficulty is a lack of money in the hands of those most interested in having good roads. Some financial help must be given to agricultural communities, a help that will, if judiciously expended, return itself many times in the decreased cost of marketing farm produce. The Pennsylvania plan which, in brief, is that where any town builds or improves a mile of road, the county and State shall each build or improve another mile of like quality seems a step in the right direction. But the general government, which controls all the great sources of income, should intervene in the aid of common roads and supplement the country and state aid on the same principle that it improves our water-courses, as neither enterprise can be advantageously undertaken by corporations.

This involves an extension of the annual or bi-annual appropriations for public improvements. All are familiar with the attacks on the River and Harbor bill, attacks which emanate from those newspapers which supply our best thought with its convictions. As the improvements promoted by the River and Harbor bills do not issue in either great schemes of original finance, or in reorganization proceedings, and are bare of advertising patronage, this

whole scheme is intensely unpopular with some classes of our community who denounce it as a swindle and carry many eminent citizens with them. This is done in spite of the general knowledge that the fall in railroad freight rates has followed the deepening of the waterway between Chicago and Buffalo and is largely due to that increased depth.

Few conversant with such matters do not know that a freight of twenty-five cents per bushel was often paid on grain between Chicago and Buffalo, before 1860, when vessels of six to eight feet draft were employed, and now that vessels of from fourteen to sixteen feet can be used, grain is frequently carried between the two ports for two cents, as the carrying capacity of vessels increases nearly with the cube of their depth. But comparatively few appreciate either the volume of the freight carried or the economy secured in its transportation, even compared with our present reduced railroad rates.

The official report of the Sault Ste. Marie Canal for 1889 shows that 7,615,022 tons of cargo passed through the canal, which was carried an average distance of 790.4 miles at a cost of one and a half mills per ton mile, and the second report of the Interstate Commerce Commission shows that the average freight charge per ton mile on our railroads for the year ending June 30, 1889, was 9.22 mills, so that the saving on the freight passing through the "Soo," compared with railroad freights, was nearly forty-six and a half million dollars. The total freight carried on the great Lakes during the same season as ascertained by the Census authorities was 27,460,260 net tons—all the figures to this point are official—and the Lake Carriers' Association estimate that this tonnage was transported 566 miles on the average, an estimate which has been adopted by the Census bureau. On this basis the total ton mileage on the Lakes was over fifteen and a half thousand million ton miles, or equal to nearly a quarter of the entire railroad ton mileage of the country, and on their assumption that the average charge for the whole Lake traffic was the same as on that passing from and into Lake Superior there was an economy, as compared with railroad charges for like service, of $119,801,734.

The total expenditures under River and Harbor bills up to January 30, 1889, from Niagara Falls to Chicago and Duluth and on the rivers running into the lakes, has been $28,038,590. As the ascertained saving on freight charges for the tonnage passing the Soo Canal for the season of 1889 was $46,466,011, the improve-

ment at the Sault Ste. Marie returned to the country in one year through cheaper freights over 165 per cent. on the total national expenditures for improving the navigation of the upper Lakes, and the estimated saving on the total Lake commerce for the year was at the rate of 427 per cent.

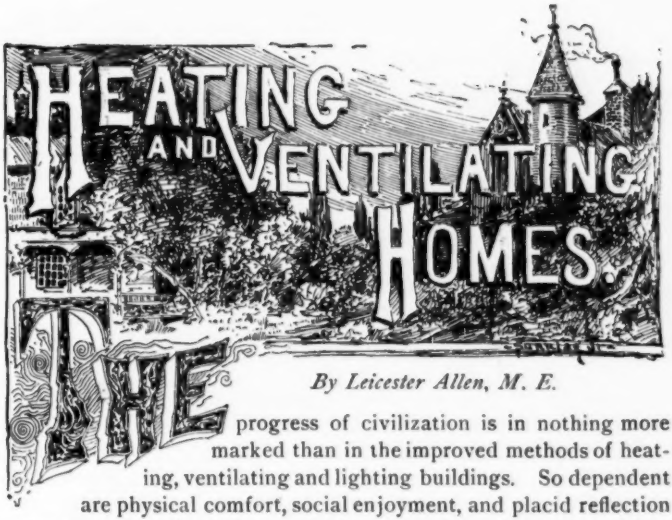
It may be of interest to say in this connection that the total appropriations for river and harbor improvements from 1789 to the present time have been $207,002,352, including the amounts covered back into the Treasury, and the saving from the canal at the foot of Lake Superior returned in 1889 22.4 per cent. on the sum of these appropriations.

The representatives of the Northwest, through a steady disregard of newspaper clamors against internal improvements, have secured a large share of the appropriations for their section of the country and a consequent early development of its resources. Up to June 30, 1882, Alabama, for instance, had had $956,142 appropriated, while Wisconsin had secured $4,616,496. The improvement of the Tennessee, which would open a valley with greater potential wealth than the Ohio to Pittsburgh, and of nearly equal length, has been under intermittent progress for sixty years. Last fall when the first commercial use of an expenditure of over three million dollars was realized, the *Railroad Gazette* called attention to the fact that the interest compounded at 5 per cent. semi-annually on the expenditures made since 1871, amounted to over two million dollars, or nearly 69 per cent. on the money expended, and some narrow-gauge statesman has limited the available depth of the improvement effected to five feet.

From Rome, Ga., to Mobile, the 700 miles of river is divided into two navigable reaches by 135 miles on which slack water navigation is necessary in some places, and this river is only 51 miles by a practicable canal and slack water route from the Tennessee, where it turns to run northwest into the Ohio. One half of the money expended on the Lakes, would have connected the two rivers and improved them for a six or seven foot navigation, giving that country another outlet to the Gulf, and making some 1700 miles of now nearly useless rivers available as a highway for the country's commerce. If this work had been undertaken with energy in 1866 or 1867, it could have been completed by 1871 or 1872, and the addition of 1580 million dollars to the assessed value of property in the South, which was made during the last decade, would have been made by 1880.

But the Representatives of that section, who constitute the chief hope of the papers in the North upholding railroad interests, have fought internal improvements as if their hopes of ultimate salvation depended on the poverty of the country they represented: so that one representative from the northeastern part of Wisconsin has probably been of greater service to his country and the world in cheapening transportation, and assisting in creating the wealth consequent on such cheapening, than all the Senators and Representatives from the section south of the Potomac and east of the Mississippi, who have served during his time.

The reduction of freight rates with the concurrent loss of profits to holders of railroad securities, has created a powerful faction in opposition to River and Harbor bills, but as better wagon roads will be directly tributary to the traffic of railroads, an extension of Government aid to common roads will probably encounter less antagonism, except from the permanently obstructive, than provisions for the improvement of water-courses have. While building and maintaining better roads will not result in the presentation of any such body of statistics as are furnished by the managers of our incorporated transportation lines, the increment to general welfare will not necessarily be less than those from larger enterprises, and the saving in cost of transportation, while possibly not more generally distributed, will issue more immediately to the small producers and consumers.



By Leicester Allen, M. E.

THE progress of civilization is in nothing more marked than in the improved methods of heating, ventilating and lighting buildings. So dependent are physical comfort, social enjoyment, and placid reflection upon warmth, light and pure air, that these things have entered into the literature of all civilized lands as similitudes of what is most attractive, noblest and best in human intercourse. The warmth of human sympathy, of imagination, of affection, of hospitality, are all household words; and what better figure could be selected to express the higher pleasures of mental and emotional faculties than *warmth* as exemplified in the genial temperature of a well ordered modern home.

I am attempting by these remarks to strongly direct attention to the truth, often disregarded, that in the planning and construction of a house intended to be a home in all that the word implies, nothing in it is of greater importance than the arrangement and construction of its heating apparatus. "How it came let doctors tell," but it is the fact, that when a house is to be built or remodeled, any amount of consideration will be given to the arrangement of rooms with reference to the positions of the piano, bookcase, sofas and beds, not even neglecting the hat-stand in the hall nor the buffet in the dining-room, but the heating appliances upon which health and comfort depend are left to be disposed as they may or *must be*, after everything else is planned. Thus the impossibility of designing a perfect heating and ventilating apparatus is often created. The heating engineer seeks vainly for good positions in which to locate heaters and registers, or, perhaps, finds them already located by an architect, who, without the slightest knowledge of the

principles involved, has simply striven to find places where they can be placed, no matter how incompatible with efficiency—and having so planned obstinately refuses to modify one iota of his conception of taste and beauty to utility. Why should he? Whoever puts in the apparatus will be required to guarantee its proper and efficient working. Thus the competent engineer quietly looks over the plans, asks the architect as to whether this or that can be in anywise changed; discovers that a good job of work is impossible; returns to his office and in a polite letter regrets that, upon looking over his books, he finds the amount of work already contracted to do will preclude his engaging to perform the work in the time specified.

Now comes the chance for the man who knows little and cares less. He bids upon the job in competition only with others like himself, one of whom gets the work, guarantees and performs it, and is paid in installments as he proceeds. A favorable day for testing the apparatus is selected, owner and architect are convinced that it is all right; he gets his final bill certified to by the architect, receives his check and retires from the scene. When the apparatus begins to develop its defects, as on a cold day after some accumulation of soot and ashes upon heating surfaces which diminish their effectiveness, or when the wind blows in some particular direction, or when some sediment has accumulated in the boiler, and when as a result some radiator persists in freezing up, etc.,—if the contractor be sought (in nine out of ten such cases he has neither reputation nor money to lose) he skulks behind the architect's certificates, and the work having been accepted and paid for, there is no redress. The architect has received his percentage also, and he retreats behind the guarantee of the contractor as an excuse for his own deficiencies. The owner generally looks up some one to overhaul the apparatus and correct such faults as can be corrected; but the faults due to the incompetence of the architect or his willful disregard of the requirements for good heating remain while the house stands. On the other hand, the architect may be fully competent to plan a system of heating, or if, as is unfortunately too often the case, he be incompetent he may obtain the aid of a competent heating engineer to assist him. Such professional assistance is always to be had if sought and paid for, and it is safe to say that in all cases when such a course is intelligently pursued, the contractor will find no obstacle to the performance of good work.

I insist that the heating, ventilation, sanitary plumbing, and

lighting of a building should be considerations of the very first importance to every architect, and that they should never be sacrificed in any degree to the desire for an elegant design. The really great architect is one who, never losing sight of these essentials, is able to design artistically under such restrictions as are imposed by them; or, if the limitations be too great for the highest achievement in art, is conscientious enough to subordinate art to utility. It was an architect of no less fame than Inigo Jones who said he had never had the oportunity to design a structure except under such limiting conditions as did not give full scope to artistic achievement. The force of what I have said will be felt by competent heating engineers, manufacturers of heating apparatus and contracting engineers generally. It is not uncommon to find almost no room left in a design for the proper disposal of heating appliances; and in some extreme cases it is well-nigh impossible, perhaps entirely so, to place enough heating surface in a building to properly warm it. Especially is this the case in numbers of the large flat buildings which apparently have come to stay in our densely populated cities. If a place where a radiator can stand be found the chances are that a steam or hot water pipe cannot be run to it; or if connected with it the pipe must be run in some indirect roundabout way sure to develop faults and cause inconvenience in continuous use. If flues are run for warm air, in a large number of cases they will be found so located with reference to the furnace that it is impossible to secure circulation in them. In many cases it will be found that inlets to cold air boxes and also chimneys are placed without reference to the environment of the building, as hills, trees, or overtopping buildings, or the direction of prevailing winds; so that while with a proper arrangement a given heating apparatus would at all times have ample capacity, at others it will be inevitably deficient. No practical or theoretical heating engineer of experience will challenge these statements. The facts set forth are the most troublesome concomitants of the business.

The first essentials to securing good heating and ventilation, no matter what system is to be used, are, therefore, a design for the structure which will render possible a good practicable scheme; and next, such a scheme laid out by a competent heating engineer, either practicing his profession on his own account or connected with a good contracting firm, all of whom having reputations to maintain have such men connected with them. To do this, you

must give your architect to understand that if he cannot or will not draw his plans in a manner compatible with a scheme, advised by an expert in heating, the plans will not be accepted. You will have to pay your architect and your expert, but we are not now considering the question of cost. You cannot get competence to serve you for nothing. No more can you get good heating and ventilation for nothing; though I have often met rich people who would place a thousand-dollar piano in their house when completed, but who deemed fifty dollars a large fee to pay an expert for plans and advice upon heating and ventilation, and who regarded a thousand dollars an extravagant price to pay for a first-class apparatus wherewith to effect it.

This leads to the subject of preparing heating plans, which is another of the disagreeable concomitants of the heating business, as now conducted. It is a common custom for architects to prepare plans without reference to heating and ventilation and to ask estimates with guarantees for heating the buildings when completed. An intelligent estimate necessitates the laying out of the work in plans and a specification. It is the custom of some of the leading houses to estimate, at least for large and important contracts, only upon plans and specifications furnished by architects or owners; and it would be a most wholesome reform if all contracting engineers would follow this example both for large and small contracts. As it now is a large amount of useless labor is performed. The plans are drawn and a specification prepared, and these are submitted together with the estimate. In a great many cases, from the plans and specifications submitted by several good houses one will be selected as the most desirable, and this will be hawked about to find a contractor who will do it the cheapest, and then the contract will be given to some one who has neither drawn a plan or prepared a specification (perhaps could not draw even a passably good plan or specification if he tried), while the ones who have done this lose their time and effort wholly. It is a consolation to reflect that the numerous "smart" ones who are willing to lend themselves to such meanness are generally swindled by a contractor dishonorable enough to use the plans of another house. This method of obtaining estimates results in injury to owners adopting it, who nearly always get a poor job of work, as well as to the more honorable contractors who are swindled out of their time and money in making the plans, specfications and estimates.

When you have obtained an approved plan and specification and paid for them, the way to get the work done at the lowest cost compatible with excellence, is to submit them for estimate to two or three responsible contractors of acknowledged skill and integrity, at the same time naming to each their competitors. To seek estimates from more than this number will be useless, for the following reasons. On the assumption that you are yourself responsible or can secure to them the payment for the work when completed they will all be eager to get the contract, and will each name the very lowest price they think will permit them to realize a moderate and reasonable profit upon a well executed job. It hardly needs to be said that, in these days of sharp competition no intelligent business man will load his estimate with an exorbitant profit, in the full knowledge that such a course will give the work to a competitor. The estimates of actual cost made by such men will vary little. They are all about on a level as to prices paid for materials and wages paid to workmen, and hence the differences in their estimates will chiefly represent difference in their ideas of profits. In any case you may be certain that the lowest of these estimates will be the price you ought accept to get the entire worth of your money. If you know any man who will agree to do it ten per cent. less, you may with justice conclude that he does not know his business, or that he means to cheat either you or his creditors, or perhaps both.

So much by way of answering the query, "Who shall I get to plan and execute the work?" You perceive that success largely depends upon your own course of procedure.

What system? This must primarily depend upon what you can afford. Hot water heating is admittedly the best in results of any known method. Steam follows next. Warm air heating next. I am of course speaking now of methods of heating for entire buildings by a single heating apparatus. These systems are also named in the order of their cost, hot water heating being more expensive in first cost than steam, although perhaps more economical of fuel even in cold weather, while in quite mild weather its superior economy is more marked. Warm air heating is cheaper in first cost but somewhat more expensive in fuel consumption than steam; but unless steam heating is performed wholly or partly by indirect radiation, a warm-air system taking its air from the outside is to be preferred for sanitary reasons. Neither is a hot water system perfect without provision for better ventilation than can be obtained when direct radiation is

alone employed. Any of these systems may work well or badly, according as it is skillfully or unskillfully erected. As they are for the most part to be attended and managed by unskilled persons, the greater the necessity that their erection and arrangement should be directed by the highest skill. Automatic regulation of draft with automatic regulation of flow of air through cold-air boxes to indirect radiators are essentials in all steam heating apparatus. Automatic water supply is also a good adjunct, though not so essential as automatic regulation of draft and air-flow; but an independent water feed-pipe and valve should never be omitted.

A good system of steam or hot water apparatus will work silently and heat uniformly all radiators and heaters comprised in it. It must be ample for coldest weather, and capable of regulation for milder weather. In the latter respect hot water heating is superior to steam. With steam the temperature can never be less than 212°F. on the surface of the radiators, while with hot water circulation they may be used at surface temperatures as low as 100F., thus imparting a gentle warmth to apartments, that without this would be too hot or too cold. Besides, with hot water systems the surface temperature of heaters and radiators is always considerably lower than that of steam radiators, except when the water is confined under pressure. In the present state of the art I for one should not want a system of hot water heating under pressure in a house of mine. It has the fault from which also steam heating apparatus, even the best, is not free; that the surface temperature of the radiators is somewhat too high, producing an effect less agreeable, and considered by many hygienists as liable to produce in the air a condition less favorable to the highest sanitary requirements than surface at a lower temperature. Water confined under pressure and heated has the quality of being superheated; that is to say, it has a large surplus of heat, which, when the pressure is released from it instantaneously, converts a portion of the mass into steam. If from any cause the pressure in such a confined mass should be largely increased, a dangerous explosion from the sudden liberation of steam might result. I feel justified therefore in recommending only one or another of three general systems for house heating, to-wit, low-pressure hot water, low-pressure steam, and warm air furnace heating. These are named in the order of their respective and comparative economy of fuel, convenience in use, sanitary effect and safety as regards danger from setting fire to buildings. I dismiss altogether the systems of hot water under pressure and of high pressure steam heat-

ing, as I believe those familiar with the latter kind of heating as exemplified in many of our large office buildings, would generally agree that it is undesirable for domestic use. In my opinion high pressure heating in office buildings has greatly injured the business of low pressure steam heating from the fact that the difference between the heat effects of high and low pressure steam are not comprehended by the general public. I would like to state this in terms plain enough to be understood by any one, whether versed in the properties of steam or otherwise.

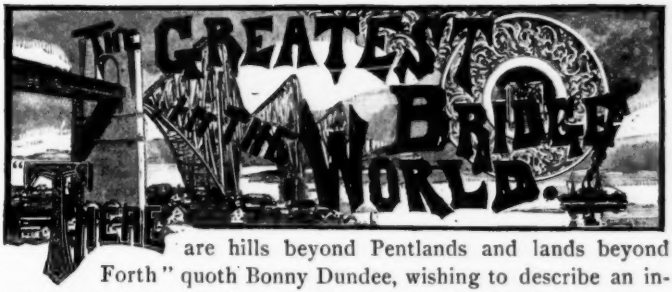
Steam at a gauge pressure of 60 lbs. per square inch has a temperature of 307° F. plus a fraction of a degree. Steam at a gauge pressure of 5 lbs. per square inch has a temperature of 228° F. almost exactly. These temperatures will practically be also those of the surfaces heated by steam at the respective pressures named. The difference between these temperatures is 79° F. and it is this difference in the temperature of the surfaces generally coupled with defective ventilation that imparts the oppressive close character to air in so many steam heated offices, and which often prejudices uninstructed persons (to whom steam is only steam, under any condition) against low-pressure steam heating. Notwithstanding these defects this system is the best yet devised for heating large office buildings when cost, economy of fuel, cleanliness, convenience and practicability are all considered.

To sum up this part of the subject; if you wish the very best results money can obtain, and can afford the expense, use a low-pressure hot water system. Extremely good results can be obtained from well-designed and constructed steam apparatus at from 25 to 40 per cent. less than a first-class hot water system will cost, while the best systems of warm-air furnace heating will cost from one-fourth to one-third the price of a first-class steam system. Of course the latter will introduce the attendant inconveniences of permeation and diffusion of dust through registers, the somewhat unsanitary condition of air brought into contact with too highly heated surfaces, and it will require considerably more coal for the same amount of heating, than either hot water or steam; but, in spite of these defects, you may with good skillful work have a house very satisfactorily heated with a warm-air furnace.

A very common question put to heating engineers and experts is, "What will either of these systems cost for, say, a house of twelve rooms?" Of course this is asked only by inexpert people, and it is about as easy to answer as the famous query, "How large

is a piece of chalk?" You should comprehend the fact that every heating apparatus is a law unto itself. Its capacity, and consequently, its cost, will depend upon the extent of exterior surface and the materials of which the house is constructed be it brick, stone or wood; upon the situation of the building with reference to its protection from winds, or partial inclosure by other buildings; upon the amount of glass in the windows, upon the location of heaters with reference to the apartments to be warmed, and upon other conditions the effect of which only expert knowledge and experience can determine. Its cost will also vary according to the amount of labor required to erect the apparatus, which differs much in differently constructed buildings, so *your* house of twelve rooms may require a cost of ten or even twenty per cent. more to heat than your neighbor's which has thirteen rooms, you getting full value notwithstanding.

What apparatus? Hardly a fair question to ask, yet one that can be answered in a general way, perhaps to your aid. In this you should be guided much by the advice of your expert, provided he be not an interested witness. But in all cases the apparatus should be obtained from a reliable, upright house who can and will guarantee in writing that it will do the work specified for it. Such houses expect to make good their guarantees, and can be made to do so by legal means if they decline. But the cases where they even hesitate to act according to agreement are extremely rare. No trade depends more for success upon correct business methods than that of heating, as conducted by first-class, responsible houses throughout the country. Only those conspicuous for these qualities have ever risen to first rank.

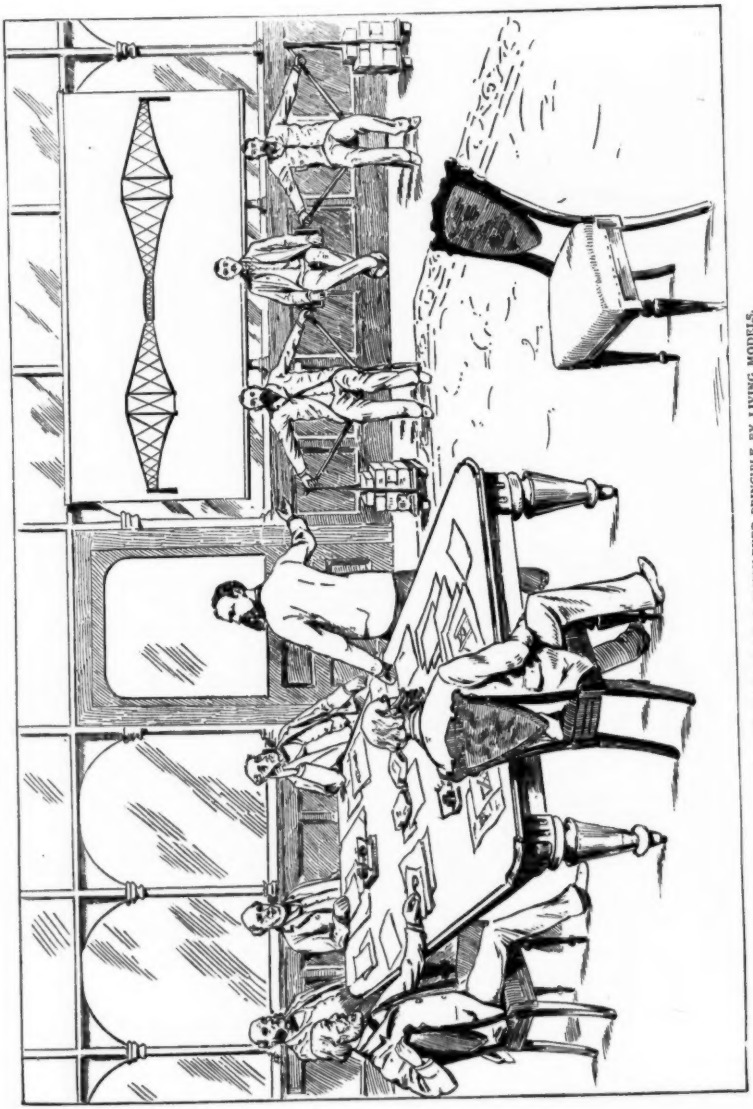


"There are hills beyond Pentlands and lands beyond Forth" quoth Bonny Dundee, wishing to describe an inaccessible place. So it was in his day, for the Forth is a stormy sea and there were only small boats then. Later came steam ferries, and now we see the huge bridge carrying one hundred trains daily over its mile of main spans and half mile of viaducts.

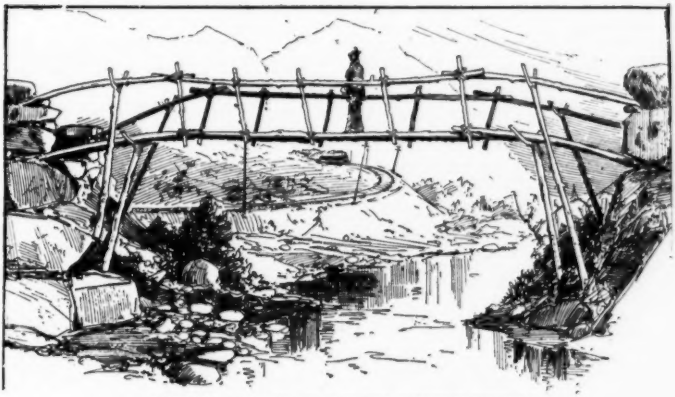
Imagine the Hudson River at New York with double its width and with a rock in the middle, the water in each channel 200 feet deep, and we have the conditions of the Forth. It can only have one pier and must be crossed, in addition to the viaduct and side spans, by two spans of 1710 feet each—110 feet longer than our Brooklyn bridge span.

There are only two types of bridge that can do this, the suspension and the cantilever. The same reasons which caused the selection of a cantilever for Niagara, although Roebling's suspension bridge close by had carried trains for a quarter of a century, decided at the Forth. A cantilever bridge can be made perfectly rigid, so that the heavy engines and cars of a railway system can run at full speed across it. Trains of 30 or 40 coal cars now run over the Forth bridge at the rate of 40 miles an hour, with a depression of only half a foot in 1700. This cannot be done on a suspension bridge as its essence is flexibility, and if we try to stiffen it we introduce abnormal strains. The elder Roebling knew this, and purposely allowed of much deflection in his bridges.

What then is a cantilever bridge? The illustration shows one made by Indians in Canada. These untaught engineers, for surely they deserve the name, pushed out the longest tree trunks they could find over the river and weighted down the landward ends with heavy stones. Then they pushed out upon them a second set of sticks and fastened them to the first, until at last they met in the



MR. BAKER ILLUSTRATES CANTILEVER PRINCIPLE BY LIVING MODELS.



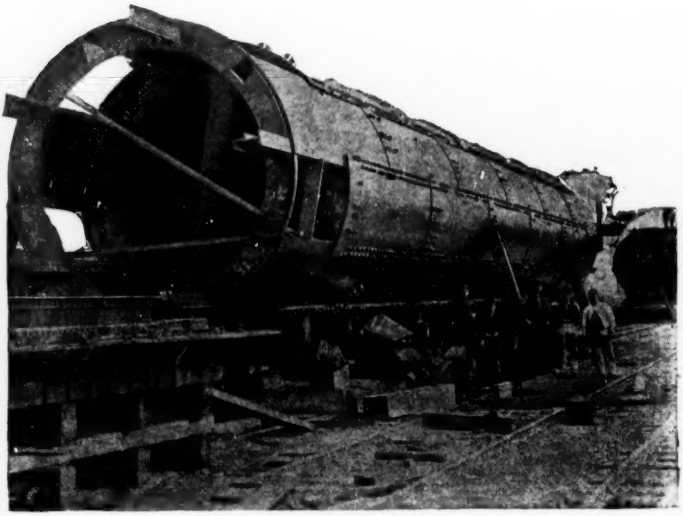
CANTILEVER BRIDGE BUILT BY THE CANADIAN INDIANS.

middle, and here was a cantilever bridge. It is not probable that they called it by a harder name in their own language.

Such was the type of bridge selected by Sir John Fowler and Sir B. Baker to span the Forth. These were very distinguished men and capital would trust them as far as it would any one, yet the undertaking was a gigantic one. Perhaps I can give some idea of its magnitude by stating that eleven spans of the ordinary American steel railway bridge of 200 feet each, would not take more metal than did the rivets used in the Forth bridge. In other words, we could span the Mississippi River with no more weight than that of the Forth bridge rivets.

After Fowler and Baker had made up their own minds as to the design of their bridge, it became neccessary to explain it to their directors. We see by the accompanying illustration how they did it. The living models illustrate the plan over their heads with perfect fidelity. Excepting the famous suspension bridge of Brazil, made of monkeys each grasping the tail of his neighbor, nothing of this kind has been done better.

There is nothing absolutely new about the foundations of the Forth bridge, although even these are very interesting. Each of the large piers consists of four columns, and each of these is supported by a circular pier of granite 49 feet in diameter. The four Fife piers and two on Inchgarvie Island stand on solid rock, falling with a rapid slope to from 7 to 37 feet below high water. These were laid dry by coffer dams, and the rock stepped or terraced to a



BUILDING A TUBE.

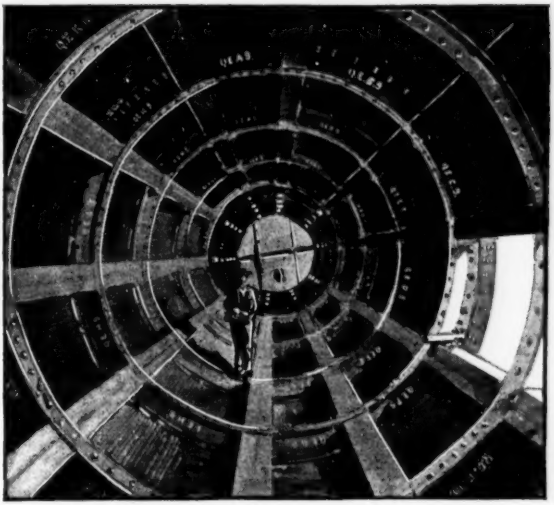
horizontal bed. It was a tedious undertaking, and the two deeper ones were executed by means of compressed air caissons. The bed was roughly levelled with bags of sand and the caissons sunk through it, the deepest point reached being 75 feet below high water.

The Queensferry piers stand upon boulder clay, and these were also sunk by pneumatic caissons to depths of from 68 to 88 feet below high water. These caissons were of a circular form and made of plate iron with double sides filled with concrete to give weight, and were 70 feet in diameter. They were fitted with air locks, having sliding doors worked by hydraulic rams for passing out the clay and boulders. On the side of each air lock was a steam engine, with its shaft passing through a stuffing box into the lock and working a drum for lifting the débris from the excavations. The clay was too hard for men to dig, and Mr. Arrol the chief contractor devised very ingenious tools, consisting of large spades worked by hydraulic rams which cut the clay like cheese. On my visit to the works in 1885 I was told that these tools had saved at least one year's time.

The size of the caissons and the weight they carried loaded the

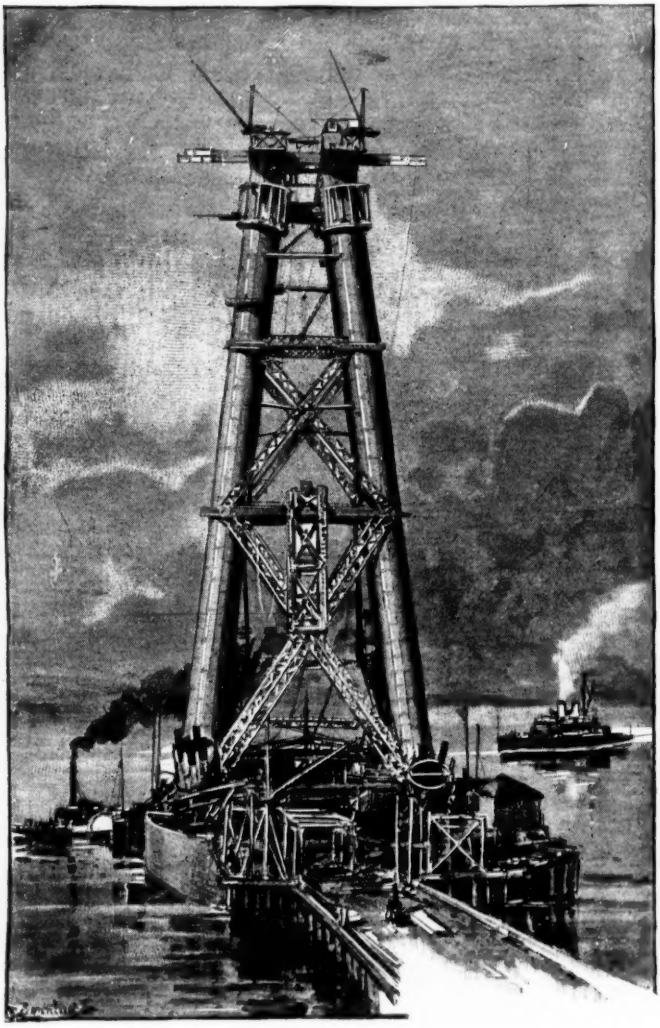
clay to six tons per square foot, and there was no settlement that could be discovered, although this is a greater load than has been usually put on clay. Its hardness warranted a practice which, though daring, has been perfectly successful. All the caissons were filled with concrete made of one part of sand, one of cement and four of broken stone. This had an ultimate strength of 50 tons per cubic foot.

The circular stone piers, 49 feet in diameter at the top and 55 feet at the base, were carried up to 36 feet above high water. The



INTERIOR OF TUBE.

load upon them under the bed plates is about 15 tons per square foot. The bed plates, which on a 500 foot span would be about 3 feet by 6 feet, were 37 feet by 17 feet, made of 15 plates rivetted together, and held down by 48 steel bolts two and a half inches in diameter and penetrating twenty-four inches into the masonry and secured by anchor plates at the bottom. These bed plates had a very important duty to perform, as they were calculated to take care of the wind pressure and prevent undue twisting and shearing strains on the masonry. These plates are in two parts and are intended to slide upon each other. Under ordinary circumstances the friction resulting from the weight is too great to allow of motion, but



BUILDING A PIER.

should the bridge be struck by a tornado the plates would slowly slide and thus relieve the masonry below to such an extent that the shear, or side strain, will be between 9 and 12 tons per square foot, which it is entirely capable of resisting. To quote Sir B. Baker: "To attempt a closer approximation than this would only serve to advertise our incapacity to appreciate the complex character of the problem and the uncertainty of some of the *data*." This sort of talk, we would say in America, shows "horse sense."

The question of wind pressure in such large spans is a most serious one, and it had been much neglected in England until the fall of the Tay bridge. Under the influence of the panic caused by that catastrophe, the Board of Trade fixed the amount of pressure to be provided for at 56 pounds per square foot, striking a bridge at any angle and acting squarely or obliquely on an area equal to twice the plane surface of the windward girders, with a deduction of 50 per cent. in the case of round tubes.

Very interesting experiments were made by Sir B. Baker on wind pressures by automatic gauges, varying from 300 square feet area down to 1½ square feet area. The large board showed smaller pressures than the small one. The extreme pressure on the large one was 35 pounds and on the small one 41 pounds, showing that the wind comes in local jets. The great difficulty however is to determine what area to take. Sir B. Baker, by a series of very ingenious experiments which we wish we had space to give here, showed very clearly that the Board of Trade requirement of double the area of the windward girder was in excess of the truth.

The next question to be determined was the allowable stress per square inch, which gives the dimensions of the parts. The original requirements of the Board of Trade were that the stress should in no case exceed one fourth of the ultimate strength of the steel. Mr. Baker believes that the rational mode is that generally adopted by American engineers, which is to assume varying ultimate resistances of the metal for different proportions of live and dead load.

Very few failures were reported of the steel, which was Siemens-Martin open-hearth steel principally made by the Steel Company of Scotland. Mr. Baker has stated that only half a dozen plates were rejected out of 12,000. This striking statement shows how dependent the engineer is upon the metallurgist. If the engineer had not been given a stronger and tougher and a more uniformly reliable material than iron, his difficulties would have been vastly increased. The engineers of the Forth bridge

were the first to use mild steel on so large a scale in bridges, although its uniform excellence had been known to naval architects for some years.

The compressive members of the Forth bridge are round tubes. These had been used by that great engineer whose loss science still deplores, Capt. James B. Eads, in his noble arches at St. Louis ; and many American engineers, myself among the number, have built many miles of bridges and viaducts whose columns and upper members are iron tubes, made of segments rivetted together, which is nothing more than the well-known Phœnix column. But the engineers of the Forth, with their desire to concentrate material along the lines of stress, had to use greater tubes than had ever before been made—twelve feet in diameter ! The interior view of one of these tubes is seen in the accompanying illustration, which is a tube equal in diameter to the new aqueduct of New York.

These tubes were made of 10 plates from one-half to one and a quarter inches thick, 16 feet long and breaking joints with each other every eight feet. They were united by lap joints, each joint covered by a continuous girder rivetted to it. At every joint there were circular diaphragms to prevent flattening and yet they did flatten three inches by their own weight before being rivetted up, and had to be braced on the inside with timber struts.

To make these tubes required about sixty miles of plate. These plates came flat from the mill, were heated in a gas furnace and bent on a curved bed to the proper radius by a hydraulic press of 1800 tons power. We have spoken of the dependence of civil engineering upon metallurgy. Here we see its dependence upon mechanical engineering. Without hydraulic power, which transforms pigmy man into a giant, it would have taken fifty years to build the Forth bridge.

The Forth bridge differs from former practice in having the manufacturing shops taken to the bridge instead of taking the bridge from the shops wherever they might be. Everybody knows that the practice in American bridge shops is to make all the different parts, such as chord pieces, eyebars, posts, floorbeams, etc., according to figured drawings. These are sent to the site of the bridge and come together on the scaffolds for the first time. In British shops the practice is to erect and fasten together by bolts at least one span in the yard. This is erected complete and then taken apart and shipped to the site and re-erected. At the

Forth bridge as special tools had to be made for everything there seemed to be no place so fit for the shops as directly at the site of the bridge. To this place all the plates and rolled sections were sent from the steel mills at Glasgow and Landore. All parts of the structure then went through the following processes :

They were sheared, planed or sawed to the exact dimensions required.

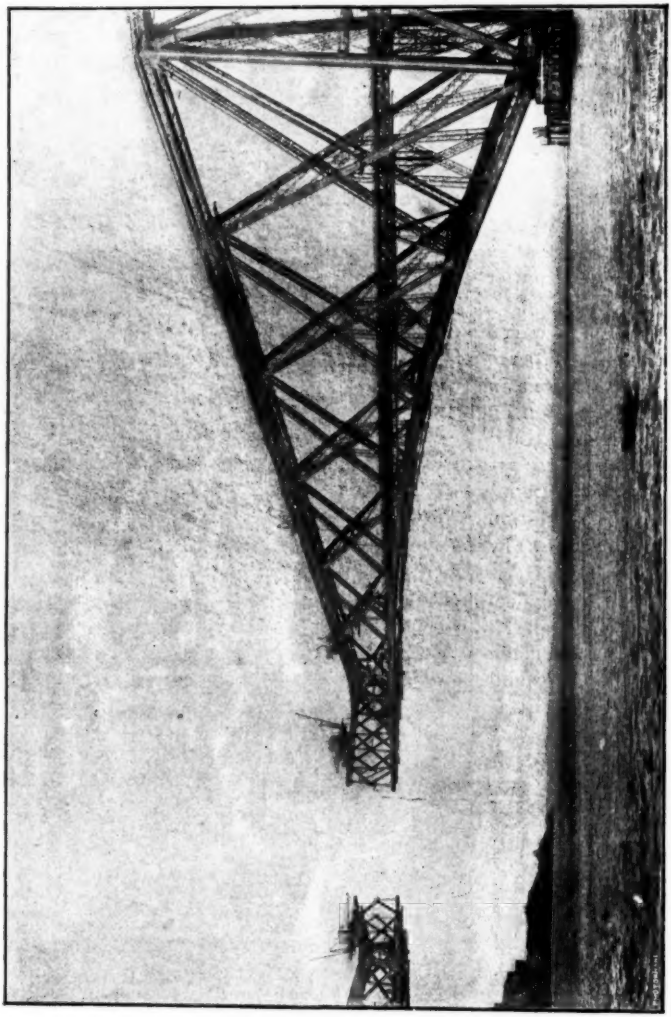
They were then fitted together in the exact position they were to occupy relatively to each other in the bridge.

The rivet holes were then drilled by power drills.

They were taken apart, again placed in final position on the scaffold, and riveted by hydraulic riveters.

The question is frequently asked, "How were the connections made?" They were made by drilling and rivetting, just as the members are made, except that they change their shapes from round to oval or rectangular, and are re-enforced by inner gussets, plates, angles, and diaphragms sufficient to maintain the same bearing or

SUNSET—THE UNFINISHED CANTILEVER.



CONNECTING TWO CANTILEVERS.

shearing pressure on the rivets as in the main members. I need hardly say that this is a work requiring the greatest judgment and skill, and a plank model full sized was made of every connection and discussed by the engineers and contractors before adoption.

From what has been said it will be evident that the problem of the erection of this great bridge was simplified on account of there being no parts of great weight or size to lift, and because all the fitting and drilling having been done in the shops, there was none to do in the stagings and every part necessarily coming into exact position.

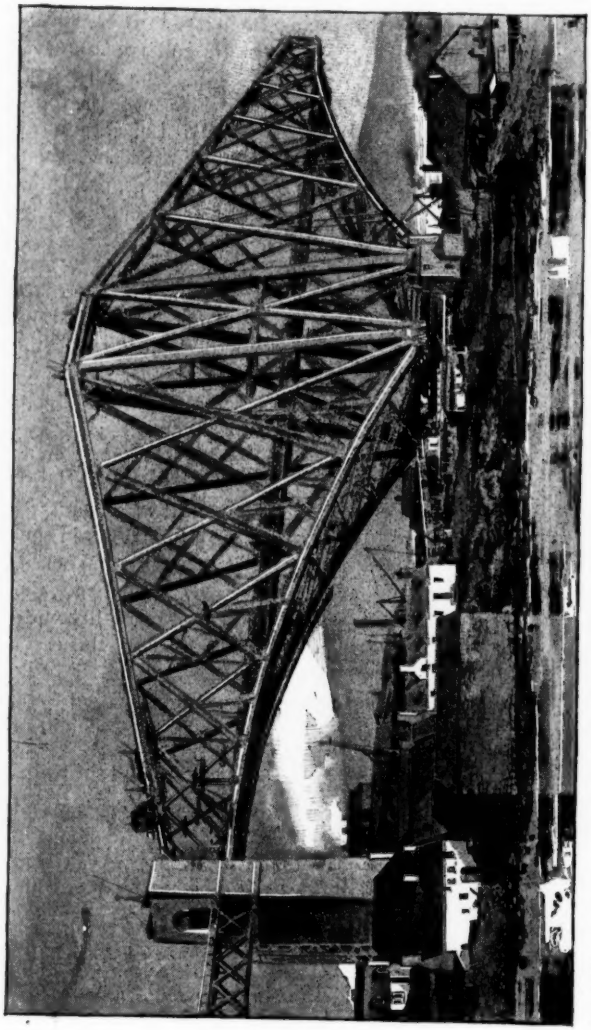
The tests of this bridge showed very satisfactory results. Two coal trains 990 feet long, weighing a ton to the foot, which is about one half the weight of an American coal train, were run on so as to reach from one pier to the centre of the middle span. The downward movement was 7½ inches and the lift at the other end of the cantilever 3½ inches. The tops of the piers, 360 feet high, moved sideways about 2 inches.

The Forth bridge is a very sensitive thermometer. There are no such extreme variations in Scotland as we have in America, but on a summer's day the temperature will vary from 50° in the shade and 70° in the sun, to 80° in the shade and 95° in the sun.

The sun keeps the Forth bridge always moving. When it shines on the east side in the morning that expands and bends the whole span about 1½ inches to the west. As both sides become heated alike, the bridge returns to a straight line but lengthens. Toward evening it begins to return and in the morning it is back again where it started. The sun also lengthens the iron piers and raises the whole 36,000 tons about one-quarter of an inch higher than at night. Sometimes a hot sun will lengthen the top chord before it can affect the piers, and then the centre droops a little. When the Forth bridge was begun there were but two railroad cantilever bridges in existence, a small one in Germany and C. Shaler Smith's fine bridge over the Kentucky River. While the Forth bridge was building nine large cantilever bridges have been completed, as shown in the table on following page.

The cost of the Forth bridge is officially given as £2,928.000, or $14,230,000 of our money, which is about the same as the cost of the Brooklyn bridge.

This sum may be approximately divided as follows: 32,000 cubic yards of material excavated, including compressed air plant, £128.-



SOUTH CANTILEVER COMPLETE.

CANTILEVER BRIDGES.

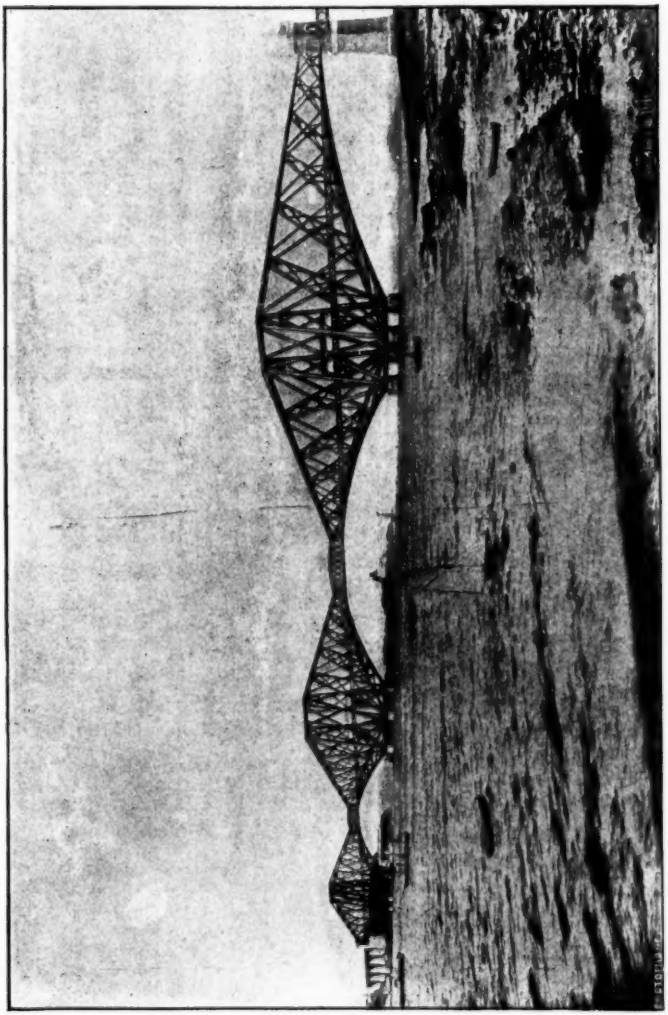
Date of Construction.	Name of River.	Place.	Names of Engineers.	Spans. No.	Spans. Length of Span.
1876	Kentucky.	Cincinnati Southern R.R.	C. Shaler Smith.	3	375
1876	Warthe.	Posen.		1	148
1883	Niagara.	Below Falls.	C C. Schneider.	1	495
1884	Fraser.	British Columbia.	C. C. Schneider.	1	315
1885	Ohio.	Louisville, Ky.	Union Bridge Co.	1	484
1888	Hudson.	P'ghkeepsie, N.Y.	Union Bridge Co.	3	550
1888	St. Lawrence.	Lachine, Can.	C. Shaler Smith.	2	408
1888	Kenawha.	Parkersb'g, W.Va.	Union Bridge Co.	1	485
1889	Kentucky.	Tyrone, Ky.	Union Bridge Co.	1	551
1889	Indus.	Sukkur, India.	Sir A. M. Rendel.	1	820
1890	Colorado.	Red Rock, Colo.	Phœnix Bridge Co.	1	660
1881 to 1890	Forth.	Scotland.	Sir J. Fowler. Sir B. Baker.	2	1710

000; 4000 tons caissons, £42,000; 140,000 cubic yards of masonry, £630,000; making a total cost for the foundations of £800,000. The total cost of the 50,000 tons of steel used, in manufacture, shops, tools, and erection, was £1,750,000; to which must be added parliamentary expenses, fees and salaries of engineers, and interest, bringing up the entire expenditure to the figures stated above. Let us hope that the engineers got a considerable share of the last item, for they well deserved it. Sir John Fowler, Kt. was made a Baronet, and Mr. Baker and Mr. Arrol were made Sir Benjamin Baker and Sir William Arrol.

Sir John Fowler is a man who has executed probably more important engineering works than any man in England, and has never been known to fail in anything he has undertaken. He is a man of very sound judgment, great executive skill, and has a rare power of choosing men. Owing to his age and delicate health he has not appeared so prominently before the public as his younger coadjutor Sir B. Baker, but his influence and sound judgment have been felt in all parts of this great undertaking.

Sir Benjamin Baker is so well known among us in America that it is superfluous for me to describe him. He is one of those men whose health being proposed at a public dinner everybody at once begins to sing, "For he is a jolly good fellow!" Great as have been his works he gives one the impression that he could do still greater ones if he had the opportunity.

In speaking of the Forth bridge he publicly said: "The merit of the design will be found not in the novelty of the principles, but



GENERAL VIEW OF THE FRITH OF FORTH BRIDGE FROM THE SOUTH SHORE.

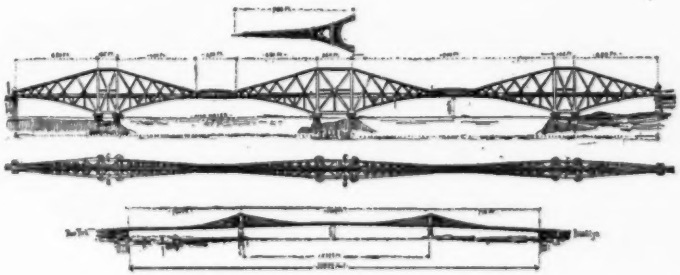
in the resolute application of well tested mechanical laws and experimental results."

At another time he said: "The success of the work was due as much to the individual and collective pluck of the workmen, as to the scientific labors of the engineers and the organization of the contractors." This was true, and a manly thing to say.

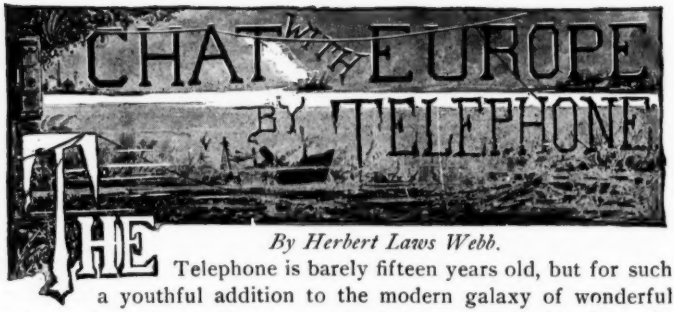
To Sir William Arrol, the chief contractor, is due all the ingenious hydraulic lifts, rivetters and other machinery worked by that power. All the shop tools and their methods were devised chiefly by him. Upon him fell a large part of the care and responsibili ties of the erection. In all these things he gave complete satisfaction to his two chiefs.

It may be asked, could American engineers build as great or even a greater bridge than the Forth? We believe that with the experience derived from the Forth bridge we could do better. If metallurgists can give us steel with greater strength than that used at the Forth and with equal ductility and uniformity, we can build spans that will surpass even those at the Forth; but I do not think we should build up each member piecemeal in its place, as was there done. I believe we should follow American practice throughout.

THOMAS CURTIS CLARKE.



COMPARATIVE SIZES OF FORTH AND BROOKLYN BRIDGES AND EIFFEL TOWER.



By Herbert Laws Webb.

THE Telephone is barely fifteen years old, but for such a youthful addition to the modern galaxy of wonderful discoveries it has made a marvellous record for itself. Scarcely fifteen years ago it was looked upon as a scientific freak, and the majority of those who were privileged to make the early acquaintance of the new-comer believed that it was doomed to an early oblivion on the dusty shelves of museums and workshops. To-day the telephone forms the nucleus of a mighty industry. Within a few years its development has become far-reaching beyond the fondest dreams of its inventor. By its agency speech is transmitted over the valleys and hills that separate great cities, and the capital of the greatest European republic holds daily and nightly converse with the metropolis of the world on the foggy banks of the Thames. The telephone promises to play an even more important part than the telegraph in knitting the nations of the earth more closely together. Telephony between countries separated by the sea is already an accomplished fact. Twenty years ago the prophet who would have ventured such a possibility would have been laughed to scorn. Who would venture to assert to-day that fifty years hence telephony between the New World and the Old will not have been accomplished, and that "a chat with Europe by telephone" will not become an every-day matter for those who shall be able to afford such a luxury?

True it is that by the light of our present knowledge it seems scarcely possible to hope for such a revolution in the world's methods of communication; but if the present rate of progress be maintained, if new discoveries arise as frequently in the future as they have in the near past, what seems impossible to-day may be a step nearer to-morrow, and each step diminishes the apparently

illimitable distance. He would be a rash prophet who would set a limit on the possibilities of electricity.

Fifty years ago the idea of telegraphing across the Atlantic Ocean would have been regarded as wildly chimerical; and even eighteen years later, when submarine telegraphy was making rapid progress, the successful laying and working of so long a cable was deemed by many to be entirely impracticable. To-day the laying of a cable two thousand miles long is a piece of work of no extraordinary importance, and as a feat of engineering ranks below many a bridge and tunnel which cause no great feeling of wonder in the pub'ic mind, while the methods of signalling through cables of such length, although involving the use of complicated and costly apparatus, have long ago been reduced to an exact science.

Fifty years is a long period in the history of electrical industry. To-day, that peculiar phenomenon of electrical conductors called "static retardation" imposes a limit on the distance to which speech can be transmitted. Perhaps long ere fifty years have rolled by, some means will have been devised whereby telephonic currents shall be rendered less susceptible to the deadening influences of retardation, and the range of long-distance telephony will consequently be enormously increased.

The telephonic current is the smallest one (in the sense of developing a comparatively microscopical amount of energy) which can be made to do any useful work; and it can easily be understood that in order to transmit this feeble undulating current over five hundred miles of wire and turn it to account at the other end, the highest pitch of excellence must be maintained in line and instrument construction. The range of the telephone has been greatly increased during the past five or six years, and it is as easy now to talk from New York to Boston or Buffalo as from the City Hall to the Battery. But the limit of distance at which long-distance telephony can be commercially successful is fast being approached, if it has not already been reached. This depends principally upon what has been said above, but to afford a proper understanding of the subject it will be necessary to give a short explanation of the science of telephony.

It has already been said that the telephone transmitter sends out the weakest electrical current capable of doing useful work. It must also be said that the transmitter itself sets a limit on the strength of the current. In telegraphy the battery current goes direct to line, and in working a long line more cells of battery

are put on in order to deliver sufficient current at the distant end to operate the receiving instrument. In telephony the battery current does not pass beyond the transmitter, in which it is transformed by means of the induction coil in precisely the same manner as in electric lighting on the alternate current converter system. This induced current is sent into the line and its energy is limited by the capacity of the transmitter, with which only a few cells of battery can be used. More powerful transmitters could no doubt be designed, and many improvements have been made in this direction ; but powerful transmitters introduce other evils, such as increasing the effects of induction from wire to wire where a number of lines run in close proximity to each other, as is of course generally the case. A weakling from its birth, the telephonic current meets many obstacles in its career, and its endeavors to do useful work are checked and restrained in various ways. The telephone receiver is operated by induced currents, and it is moreover an extraordinarily sensitive instrument. It is a very easy matter, crowded as the earth now is with wires, for induced currents from other lines—telegraph, electric light or electric power—to get into a telephone line and so occupy the attention of the receiver that it can pay none to the impulses legitimately belonging to it. The defects of the instruments themselves have already been explained ; the transmitter is not sufficiently powerful and the receiver is too sensitive, but any attempts at altering this state of affairs are restrained by the knowledge that other serious difficulties in working would be introduced.

The part which the line plays in limiting the distance to which speech can be effectively transmitted can now be referred to. When the Atlantic cable was laid, great difficulties were encountered in working through it at any satisfactory rate of speed, and it was not until Sir Wm. Thomson discovered the law governing the speed of signalling through submarine cables, that a properly designed core was made which would facilitate working at a fair speed through such a great length of cable. In Sir Wm. Thomson's law it was laid down that the speed of a cable depends upon its conductor resistance and inductive capacity, and in designing submarine cables these factors are considered in relation to the prospective length of the cable in one section, for determining the speed at which the cable can be worked when laid. A similar law has been applied to the operation of telephone lines, and it appears moreover that when the resistance and capacity of a line increase

beyond certain values that telephonic transmission over that line is no longer possible.

The current travelling over a well insulated line used for signalling is affected by two qualities of the line, *i. e.*, by the resistance of the conductor, and by its inductive capacity. Resistance may be looked upon as a sort of friction that has to be overcome by the current, and inductive capacity as a sort of absorption which tends to check the flow of the current by absorbing a portion before the charge can pass out at the distant end of the line. Both resistance and capacity are measurable in exact units, the ohm and the microfarad, and tests are made on all lines used for signalling purposes to ascertain exactly how many ohms and microfarads per mile they are endowed with. The telephonic current is peculiarly susceptible to these retarding effects, and it has been determined by experiment that when the resistance and capacity of a line exceed certain values, telephonic transmission over that line is no longer possible. From these experiments a simple formula has been deduced which expresses the idea very clearly. The total resistance of the line in ohms is called R, and the total capacity in microfarads is called K. Now when the product, K R, of these two exceeds a certain number, speaking over the line becomes impossible. Thus in a line having a resistance of 1500 ohms and a capacity of 10 microfarads, the product, K R, would be 15,000, and speaking would not be possible. If the line had a resistance of 1250 ohms, K R would give 12,500, and at this figure speaking is possible. Briefly stated the formula is as follows:

When KR = 15,000 speaking is impossible,
" " = 12,500 " " possible,
" " = 10,000 " " good,
" " = 8,000 " " excellent,

and so on.

With aerial lines it is not difficult to keep the KR within reasonable limits, as the inductive capacity of an overhead wire is comparatively low, and it is not increased very greatly by using a heavier wire, which of course reduces its resistance. For instance, a copper wire weighing 200 lbs. per mile has a resistance of about 4.5 ohms per mile, and when strung at a height of 30 ft. above the ground, an inductive capacity of .015 microfarad per mile. The KR of such a line, 400 miles long, would be 10,800, just overstepping the good speaking limit; and if the line were 500 miles long the KR would be 16,875, or well beyond the limit at which speaking

is possible. If a wire weighing twice as much were used it would have a resistance of 2.25 ohms and an inductive capacity of .0156 microfarad per mile. The KR of a line 500 miles long built with this wire, would be 8775, or well within the limit of good speaking ; while a line 600 miles long would give 12,636, which is about the utmost figure at which speaking is at all satisfactory. It is evident, therefore, that in order to obtain a long-distance telephone line over which the speaking shall be good, we must use a wire having a low resistance and a low inductive capacity. The figures given above for inductive capacity are for wires suspended at a height of 30 ft. above the earth ; the capacity is lessened by increasing the distance between the wire and the earth, and as most of the long-distance telephone lines in this country are carried on very high poles, their inductive capacity averages lower than the figures given.

When we come to telephone through cables, underground or submarine, the bugbear of inductive capacity makes itself felt in a most unmistakable manner. The best type of telephone cable known to-day has a capacity of from eight to ten times that of an overhead wire, and this with a conductor having nearly eight times the resistance of our aerial wire weighing 200 lbs. to the mile. It is evident that these figures run up our KR and bring down our speaking limit in an astonishing manner. Thus, 55 miles of cable having a resistance of 35 ohms a mile and an inductive capacity of .1 microfarad a mile, would give a KR of just over 10,000; which shows that the utmost distance through which it would be possible to telephone through such a cable would be about 55 miles—probably 50 miles would be nearer the mark for good speaking. In a cable designed especially for long-distance telephony where expense was no object, the size of the conductors could be increased, thus reducing their resistance and extending the limit of speaking.

With submarine cables the case is still worse. Cables that have to be laid in water must be insulated with gutta percha or India rubber ; and these materials have a much higher capacity even than the insulating substances (such as cotton, paper, etc.) used for underground telephone cables. The inductive capacity of submarine telegraph cable of the ordinary type is about .33 of a microfarad per mile, being three times as high as that of the underground cable and from twenty to thirty times as high as that of an overhead wire. The resistance of the conductors of submarine

cables averages from 5 to 10 ohms per mile, although one or two of the Atlantic cables have a conductor resistance of only 2.25 ohms per mile and an inductive capacity of about .35 microfarad per mile. When we see that the KR of even one of these exceptionally large cables amounts to over 3,000,000 it is evident that "A Chat with Europe by Telephone" must still be looked upon as an enchanting vision of the future. With a submarine cable of this design it would be possible to telephone between two points separated by 100 miles of water, and that at least is a reassuring fact. If one hundred miles to-day, why not five hundred next year, and two thousand in the next century?

It may seem anomalous that the limit given for an underground cable should be only about one half the distance given for a submarine cable, but in the former case the calculation was made for the ordinary type of cable used in city telephone work. This cable contains 100 conductors in a diameter of about two inches, and the conductors are necessarily small and their resistance high. If it were necessary to design an underground cable for one or two circuits only, one could be made through which it would be possible to speak 100 miles or more, but of course such a thing is never thought of, as it would be commercially impracticable. To establish a submarine telephone line 100 miles long it would be necessary to lay two cables of the dimensions cited, as the use of metallic circuit is absolutely necessary; and the line would have to earn about five dollars a minute to be commercially successful.

There are two long-distance telephone lines at present working in which submarine cables of some length are employed. The first of these is the line completed about eighteen months ago between Montevideo and Buenos Ayres. Its total length is about 180 miles, of which 23 miles are of submarine cable, laid across the mouth of the River Plate. The overhead line is built of extraordinarily heavy wire weighing about 850 lbs. to the mile, the resistance being less than one ohm to the mile. The line is metallic circuit throughout and there are two cables laid side by side across the river. The speaking is said to be excellent, which is not at all surprising as the KR is less than 5000, although I have seen it in various places erroneously stated as being 10,400. With such a wide margin, it is evident that the constructors of the line might have saved themselves a lot of money by using a lighter wire.

The second submarine telephone line is that recently opened between London and Paris, which enjoys the distinction of being the

first international telephone line established between two countries separated by the sea. The distance between the two capitals is about 275 miles, of which 254 miles are made up by the landlines, 74 miles on the British and 180 on the French, the cable across the British Channel being 21 miles long. The landlines are of copper weighing 400 lbs. to the mile. The cable is of special design, elaborate calculations having been made to enable those entrusted with the construction of the line to specify just the class of cable required for the work. It contains four insulated conductors, there being two separate circuits, for each of which two conductors are required. These conductors have a resistance of about 7.5 ohms and a capacity of about .304 microfarad per mile. The total resistance of the metallic circuit is 1440 ohms and the total capacity 5.142 microfarads. This gives for the value of KR 7400, a figure well within the limits of good speaking. Conversation over the line is described as being all that can be desired.

No telephone engineer can feel ashamed of the progress that has been made in telephony during its short history as one of the commercial applications of electricity, but many onward steps, however, are needed, many improvements and many new discoveries, before we can see our way clearly to the establishment of telephonic communication between the New World and the Old.

By William L. Saunders, M. A., S. C. E.

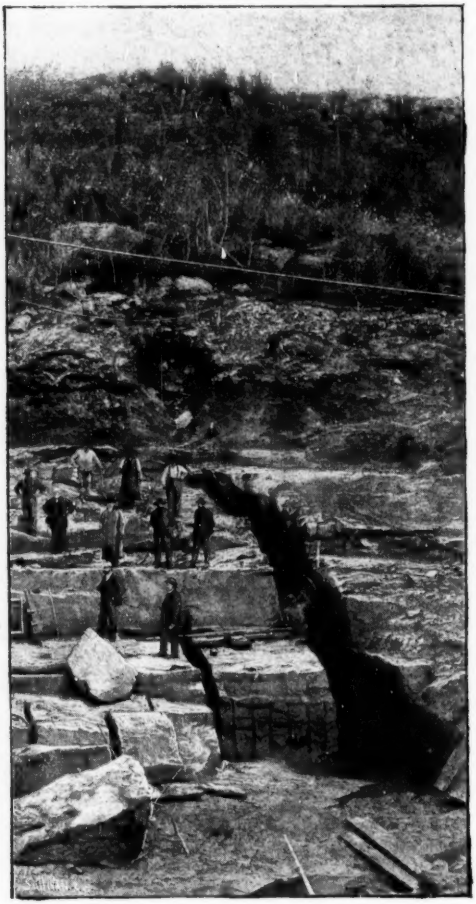
WHILE waiting for a train at Berea, Ohio, a few years ago, I was accosted by a young, handsome and intelligent quarryman, who, in a voice that seemed to come from his boots, said: "I heard you were going to New York today so I got a day off to see you and ask your help in getting something to do besides this channeling with a pick. I would like to learn to run one of your machines, or do anything but this grave digging. I feel that I am beginning to get the stone consumption, my voice seems to sink deeper every day and this is one of the sure signs. My father died of it when I was a boy. His father died of it, and I can count a half dozen men in the family that swung a pick in the quarries until we swung them in their graves—yes, and each one of them has got a stone slab over him and every time I see it I think of it as the stone that killed him."

This poor fellow may have carved his grave-stone ere this. Though profoundly impressed with his story, I was compelled to tell him that only expert mechanics were wanted in my line, but he was strongly advised to change his trade—to do anything rather than keep on in this rut of death.

Up to recent years the process of sandstone quarrying in northern Ohio involved the cutting by hand of trenches from eighteen to twenty-four inches in width and some ten to fifteen feet in depth. The quarryman was thus compelled to stand in this narrow ditch in the midst of an atmosphere of dusty grit. He usually cut by the foot and made good wages, but the span of his life was about seven years, and a post-mortem (when as on rare occasions such distinguished consideration was accorded) revealed in the lung cells small triangular or pyramidal particles of stone which

had steadily mocked the bacillus in robbing him of his breath of life. Indeed the lymph that cures stone consumption is an ounce of prevention.

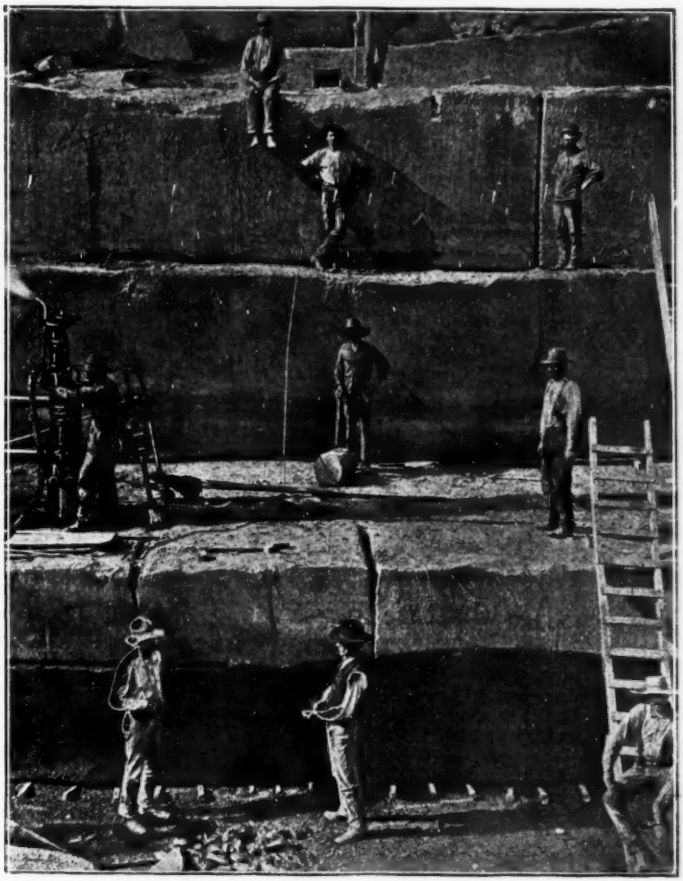
Fortunately very little of this hand trenching is now done in America, yet it is not entirely obsolete. In sandstone quarries it should be prohibited by law.



THE "RUT OF DEATH."

This system of hand trenching dates back to the Pyramids. The Quarryman stands in a narrow ditch in an atmosphere of dusty grit. He makes good wages, but the span of his life is about seven years. He dies of "Stone Consumption."

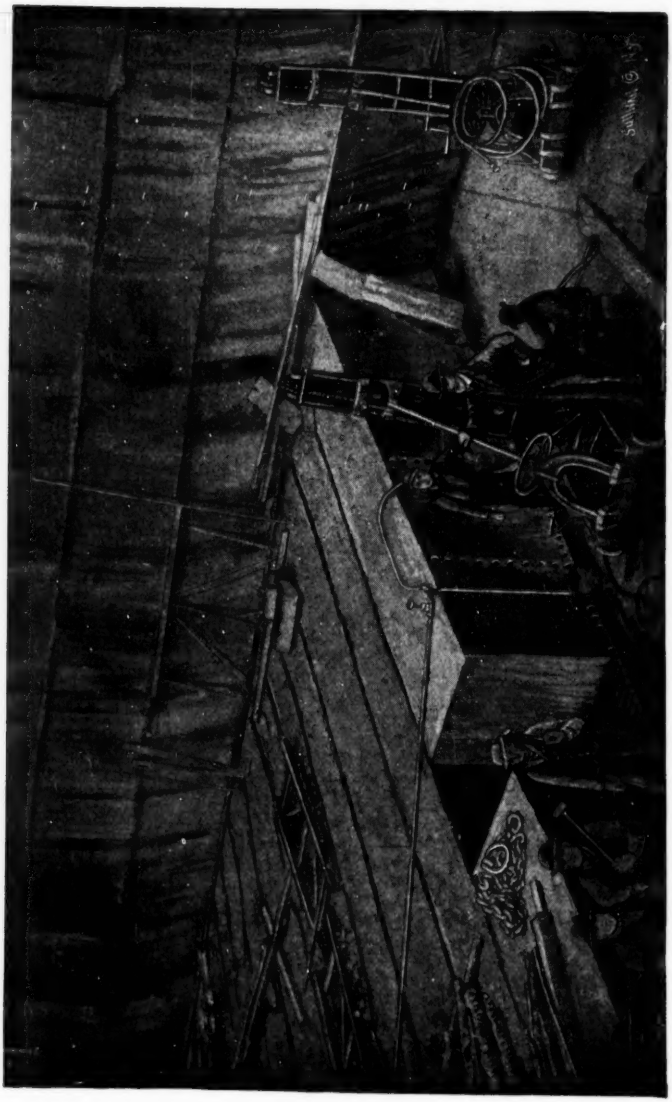
But the quarry industry in America is as a pebble when compared in magnitude with that of Europe. We are too young and inartistic to appreciate the full value of stone in structural worth. We are too busy to wait while one stone is laid upon another, so we devastate our forests and build of wood. Sometimes the law takes us in hand and insists upon a less inflammable material. We then buy brick for so much a thousand and inflame the eyes of future gener-



QUARRYING BY THE CHANNELING PROCESS.

Illustrating a type of the best methods of quarrying in America at present.

ations with red rows of this cheap and oft-times painted counterfeit of stone. Imagine the Milan Cathedral, St. Paul's, London, or the City Hall, New York, built of rusty brick! Picture the Sphynx done in brick with occasional stone trimmings about the nose and ears! But to draw our illustrations from points nearer home, look at the city of Philadelphia! Perhaps this article had its inception

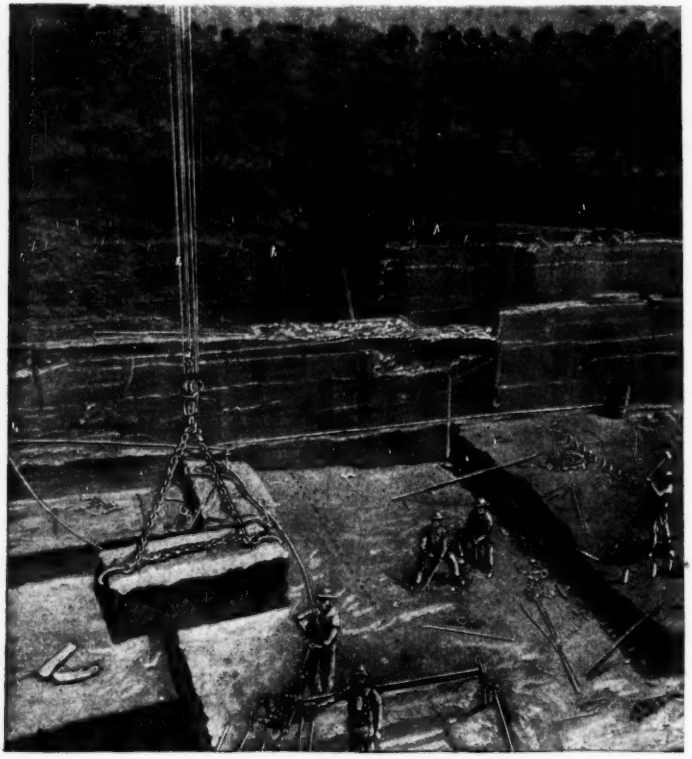


A GEORGIA MARBLE QUARRY.
Showing the best methods of channeling and gadding.

on the front platform of a Philadelphia street car when the editor of this magazine looking about him, was inspired to ask: "Have we neglected quarrying?"

The Art of Quarrying is "as old as the hills." It antedates history. Through its mute relics we have the preface to the history of the human race. The Egyptian quarries at Syene produced the syenite out of which was hewn Cleopatra's Needle. Our own Quincey granite is almost identical with the Egyptian syenite. Quarries of sandstone and limestone on the banks of the Nile furnished the material for the temples and monuments of Egypt. The great Pyramid of Cheops was built about 3000 years before Christ. It was 480 feet high and 764 feet square at the base. Certainly the Egyptians do not seem to have neglected quarrying; but if it be true that 100,000 men were employed for a period of thirty years upon the construction of this pyramid, it appears that they neglected pretty much everything else. A great deal of mysterious and useless speculation has been indulged in as to how these pyramids were built. A trip to the Runcorn quarries in Cheshire, England, or to the excavations on the Manchester Ship Canal will teach one how the stone was quarried in Egypt.

Here we are almost in the twentieth century quarrying sandstone by picking trenches in order to make release faces and drilling holes by hand. That the pick and hand drill were known to the ancient Egyptians is not doubted. They were deprived of the use of blasting powder, but explosives are not essential in dimension-stone quarrying. We still use wedges, plugs and crowbars, tools which we have inherited from our fathers. Some of the blocks in the Pyramids have large circular holes in them. This indicates that they were lifted by derricks. We have the advantage of the steam hoist, but this only enables us to lift heavy weights quickly. So far as the actual work of releasing the stone from its place is concerned, the European quarries have made little or no advance since the days of the Pyramids. A writer has recently referred to the dimension-stone quarries of England as follows: "With some stratified rocks, such as sandstone, a good many of the best stones are procured without the aid of gunpowder. *Hand tools alone are used*, because blasting is apt to cause rents and otherwise shatter portions which it is desirable to keep solid." He then proceeds to describe a system of "driving wedges with hammers," that has doubtless been known since our ancestors dicovered how to chop wood.



BREAKING UP AND LIFTING THE BLOCKS.

Notwithstanding the enormous use of stone for building and monumental purposes in Europe there is scarcely a single channeling machine in use there ; yet I have found by recent investigation that the wages of skilled quarrymen are high, almost if not fully equal to American prices, and that they have been steadily rising during recent years. An English authority states that in dimension-stone quarries only about one-fifth the product is utilized. In this same connection it is singular to note that with all our Yankee skill only from *one-twelfth* to *one-nineteenth* the gross product of slate quarries is sent to market. According to the Eleventh Census the total output of slate in the United States, in

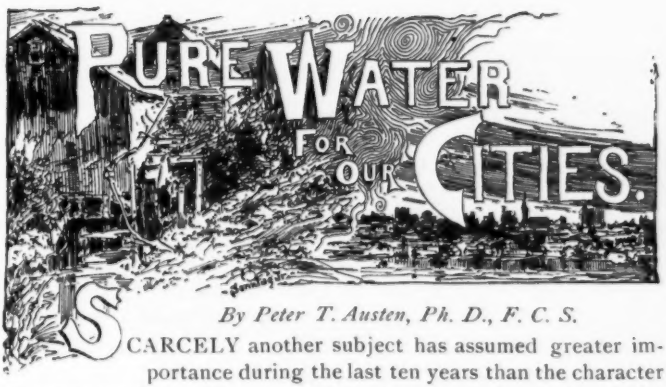
1889, is $3,444,863. Adding five per cent. as Democratic salve for the Porter census, we have $3,617,106. Based on the minimum loss (one-twelfth) we find that $39,788,166 worth of slate has been thrown into the dumps and lost in one year. Much of the material in the dump is, of course, unsound. Our methods of slate quarrying are perhaps less advanced than in any other class of stone, but the loss in marble and building stone would reach higher figures than those stated because of the increased value of the product.

The steam channeling machine has been of vast importance to the marble industry of America. Without it the system of deep quarrying followed in Vermont would be almost impracticable. It has reduced the cost of quarrying, has saved stock and has largely increased production. It is because of the use of the channeling machine that marble is beginning to be one of the important factors in the building trade. The Vanderbilt mansion now under construction at Newport will compare favorably with the temples of Greece and the palaces of kings. The marble is from Tuckahoe, N. Y., and is quarried by machinery. But channeling machines have never been successful in granite, and even in marble their capacity is limited. What is needed is a machine capable of rapid cutting in stone as hard as granite. Such a machine would have a high capacity in marble, limestone and sandstone, and would reduce materally the first cost of production. There is also much room for improvement in our systems of handling and finishing. The material itself has little or no value as it is deposited by nature, and there is plenty of it to be had. The high cost is represented by the labor put upon it.

The importance of the stone trade can scarcely be overestimated. Every one admits that "flagging" makes the best sidewalk. Slabs of granite or bluestone make our gutters and curbs; we pave our busy streets with granite blocks, and the buildings which overlook all this are a product of the quarries. Abutments, piers, arches, retaining walls, foundations and monuments, are of stone, and though our engineers and architects are posted as to the best stone to use and how to apply it, few, if any, pay any attention to its production. Ask an architect to describe the process by which the stone he uses is released from its natural bed, and though some of them have an idea of the steam drill, blasting, plugs and feathers, yet the process of quarrying in all its details is a hidden art. They have never thought it worth their

while to look that way. We have civil engineers, mining engi neers and tunnel engineers, but who ever heard of quarry engineers? Volumes have been written upon mining and tunneling, but where is the book on quarrying?

When engineers advance the art of quarrying in proportion to the progress made in less important fields, we may then expect that the public will become educated to a more general and artistic use of stone. The veneer of rubbed and almost polished brown stone that has been slapped like so much sand-paper upon the Fifth Avenue fronts in New York, will then give place to blocks of rock-faced or hammered stone, laid upon its bed as nature produced it, looking like stone and not as so many panels of wood. Let us combine nature and art, beauty and durability.



By Peter T. Austen, Ph. D., F. C. S.

SCARCELY another subject has assumed greater importance during the last ten years than the character of water-supplies. The wonderful progress of chemical and biological investigation, which has shed a flood of light on many matters, hitherto but little understood, has been particularly noticeable in this field of inquiry. It has been proved that water may convey diseases, and even when bright and sparkling may be superlatively deadly. On the other hand, water containing a large amount of turbidity and appearing quite unusable to the ordinary observer, when the turbidity is removed, may be found to be pure and healthful.

The health of a community is its most important consideration, and until a high health-rate is established little can be hoped for in its development; for otherwise its prosperity will be limited and its population must be transient. The misfortune that most surely robs the bread-winner of his energy, is continued illness in his family. If sickness strike the bread-winner himself, the condition of affairs may become still worse, for then the family may cease to become self-supporting, and thus a blow may be struck at the prosperity of the community. The terrible effects of ignorance, carelessness or thoughtlessness in regard to the polluting of water-supplies has been too often told in the horrors that have followed. The average man is quite careful to see that the vegetables he eats are cleaned, and if meat is tainted he will not eat it. But any liquid which comes out of a hole he digs in the ground, so long as it is clear or does not taste too bad he drinks and gives to his children. Even when death invades his household he may be loath to believe that the well from which his grandfather drank

can be a source of danger, forgetting that the sinking of cesspools on all sides must surely in time pollute it. Many an old proverb has been given a fresh significance by science, but none more striking than the one which reads, "Let well enough alone."

To be safe for drinking, water must be free from the polluting effects of refuse from factories, soakage from cesspools and other abominations; while for use in manufacturing, it should be free from suspended matter and not contain enough mineral substances in solution to cause scale in boilers or to produce injurious effects in the industries in which it is employed. The turbidity of the water makes great trouble and prevents entirely the development of many industries. There are parts of the country which have everything in their favor except the water. Some waters, like the Mississippi for instance, are filled with such fine matter that weeks will be required for it to settle, even when at perfect rest

In view of the immense importance of the purity of the water supply to the health, cost of living and thrift of a community, one would naturally expect to find many processes in use for purification. In Europe many methods are being used with more or less success. In this country the subject is just beginning to receive the attention it demands, but with characteristic American energy and ingenuity, American engineers have already attained results not equalled on a large scale, in my opinion, by any yet obtained abroad.

To filter a small amount of water is not a difficult matter, but to filter millions of gallons a day requires ability of a higher order; for some of the most intricate problems of engineering are involved. In most of the systems employed abroad sand filters are used. The water is usually allowed to remain at rest in settling basins until the heavier matters have deposited and then is passed to the filter bed, through which it oozes slowly. This type of filtration has several serious objections. It is slow, and hence unable to meet heavy draughts on it, as in the case of fire. The filter-beds acting tardily may become foul, which leads to the rapid and enormous development of bacterial life in them, and this may cause the water to become biologically less pure after passing through them than in its original state. There is no quick way of cleaning the filter-beds. In fact, there is no method of simple filtration known that is competent to handle on a commercial basis the water supply of a large city.

The next step in the evolution of successful mechanical filtra-

tion was the addition to water of substances which re-act chemically with the bicarbonate of lime present in all natural waters, and form a precipitate which assists in removing the suspended matters by filtration. The addition of chemical substances to aid in clarifying water is very old. Thus in Exodus XV., 25, it reads, "And he cried unto the Lord : and the Lord shewed him [Moses] a tree, which when he had cast into the waters, the waters were made sweet." Interesting references can also be made to methods of sweetening water used in India and Egypt. The most efficient of these substances are those which produce in the water precipitates of a gelatinous nature. The gelatinous precipitate thus formed in the water entangles and agglomerates the minute particles of suspended matter, be they mineral particles or microbes, and forms masses of sufficient size to be easily removed by the filter. In fact the process is not unlike the good old method of clarifying coffee with the white of an egg. Of the substances which produce in natural waters gelatinous precipitates, alum is the most readily obtained and is not surpassed in efficiency by any.

If a water like that of the Mississippi, which is filled with white suspended matter, or of the Raritan, which is filled with the typical New Jersey red mud, is passed through a sand filter, clarification is not effected. It can be filtered and refiltered but it will still come through with an opalescence and not be "bright." If to these waters a minute amount of alum is added, and the water then passed through a sand filter, it will come out perfectly clear and bright. Indeed, the change is very striking to one who is not familiar with it. The alum and the bicarbonate of lime, which is in the water, re-act on each other chemically. The alum is decomposed and a gelatinous precipitate of aluminic hydroxide, mixed with a basic aluminic salt, is thus formed. The most searching chemical examination fails to show the slightest trace of alum in water that has been treated with the proper amount of it and then filtered.

Alum has been used for many years as a "coagulant" for water with excellent results. The treatment usually consisted in adding a certain amount of alum to the water, mixing it well and allowing the water to stand until the precipitate settled, after which the clear, supernatant water was run off to the filters. While in this way a bright water was obtained, there were still difficulties which prevented commercial success on a large scale. The subsidence plant was unwieldy, and the same difficulties existed with the fil-

ters that have been mentioned. Three obstacles remained to prevent the commercial success of filtration of water on the immense scale that large cities require. The first was the difficulties attending the cleaning of the filter-beds; the second was the time required for filtration, and the third, the great size of the filtration plant.

It was reserved for us in America to solve the problem in a most ingenious way, and to devise a process that has made the cleaning of the filter-beds simple and effective; that has diminished the time of filtration to a practical minimum and has greatly reduced the size of the apparatus.

The principles of the process now generally in vogue here, are briefly as follows: On its way to the filter the water receives the addition of a minute amount of a saturated solution of the coagulant, usually alum. The amount of coagulant added varies with different waters, and even with the same water at different times of the year. Usually it amounts to about one-fifth to one-third of a grain to the gallon. The water having received this small dose of coagulant, so small that it seems incredible that it should produce such remarkable results, passes without stopping to settle, directly to the filters. The most generally adopted form consists of large closed cylinders of boiler iron filled with sand, or a mixture of sand and coke. The coagulated water passes down through these filter-beds and comes out clear and sparkling, as delicious and as tempting as a mountain spring.

Let no one think that such a process is unnatural or that it yields a water containing chemicals. In the first place, as I have already explained, the coagulant does not remain in the water, and in the second place, beyond a doubt this process of purifying takes place in Nature. Water percolating through the earth meets with the acid products of vegetable decomposition, which act on the compounds of alumina and iron in the earth, which it meets, dissolving them, and these compounds in their turn act on the bicarbonate of lime in water in the same way as alum, coagulating it. The first stratum of sand or similiar material will now act as a filter, and the pellucid mountain rill is the result. In fact, Nature's processes are usually successful, and the wise man imitates them when he can. Nature, however, is not content with coagulating and filtering water, but at the first opportunity sends it tumbling over some precipice, to fall against rocks and be dashed into spray until it reaches the bottom a mass of foam.

In doing this Nature effects in a simple way something that has greatly perplexed engineers to imitate, *i. e.* to aerate water in a practical way. This aeration fills the water with myriads of minute bubbles of air. The surface of contact between the water and air is immense, owing to the enormous number of air bubbles. In this way the water is subjected to the powerful influence of the oxygen of the air, which destroys the dissolved organic impurities and not only kills many of the lower forms of life, but makes the life of many others hazardous by removing the organic matter on which they feed. Our engineers, however, who always watch Dame Nature sharply, have succeeded in taking the hint offered by her, and have acted on it in a truly practical way. Of course a water purifying plant is rarely in a position to introduce a real water-fall on the scale that Nature is pleased to do, although such an adjunct might be a great attraction, even if expensive. So the aeration of water has been effected in the following way. A large vertical pipe many feet in length is turned back on itself so as to form a great U. Into one end of this the water is injected and falls tangling up the air with it and emerging from the other end as foam. Water so aerated takes hours to lose its air, so minute are the bubbles. The effect of this aeration is to oxidize the dissolved organic matter and greatly purify the water.

To return now to the filter. After a certain duration of filtration the filter-beds become so clogged with the separated coagulum and filth that filtration becomes difficult, and if allowed to go on would soon yield a foul water from the growth in them of micro-organisms and instead of purifying would render the water organically less pure. Long before any danger of such a catastrophe the cleaning of the filter-beds takes place. To accomplish this the current of water is reversed, and instead of flowing down through the filter-bed, is sent with great force up through it from the bottom. The entire bed of sand is thus lifted and floats, as it were, on the ascending stream of water, yielding up all its impurities, which escape with the water through a waste pipe. The wash water of a large filter awakens strange thoughts in the mind of an observer and does not increase his relish for unfiltered water. To the biologist, however, it is a continual source of delight, for it is the concentrated essence of germs, microbes, and diatoms, and reeks with organic filth of every description. The washing of the filter is continued until the wash water runs clear, when, by turning a few valves, the flow is reversed again and filtration is resumed. So

simple are the operations of filtration and washing the beds, that one man can handle a plant filtering several millions of gallons per day.

The effect of this method of filtration on the purity of water is most remarkable. Thus the analyses of the water of the city of Atlanta, Ga., before and after filtration furnish incontestible proof of the success of the process there employed.

	Unfiltered.	Filtered.
Total solids	8.03	3.60
Oxygen absorbed	——	0.03
Albuminoid Ammonia	0.16	0.03

This city has a battery of twelve filters with a capacity of nearly 4,000,000 gallons per day. Before the introduction of the filtering plant the water could not be used except for sanitary purposes. Now the filtered water is the best there is in the city. The cost of a million gallons of filtered water delivered in the city is $3.83.

The remarkable action of mechanical filtration in the removal of organic life in water is also marked and is of the greatest importance. It is now a well-recognized fact that many diseases are conveyed by water, and reach us in the forms of microbes, or disease-seeds. From the standpoint of the hydraulic engineer, however, so long as the microbe is a particle of insoluble matter it can be removed as easily as any other particle of solid matter, clay, for instance. The microbe and the particle of clay become alike entangled in the gelatinous coagulum, and are removed by the filter-bed. Dr. Charles V. Chapin, Superintendent of Health of Providence, R. I., has made some most interesting investigations in the water filtered by the filter-plant at Long Branch, which is one of the finest yet built. In the unfiltered water he found in one cubic centimeter 298 organisms. *In the filtered water only two*—Nature, herself, cannot do better than this.

Every community is threatened sooner or later with an attack that is far more disastrous than war. The growth of the place, or the increase of towns or factories near the water courses which supply it, with ever increasing certainty will poison its water-supply, and then begin to arise the deadly attacks on the community. The increase in the rate of typhoid, the children's troubles in summer, the inexplicable sicknesses which cannot be traced. Property depreciates and men move away from the place which is filled only with sad memories. Insecurity rules. How many places could be listed here. It does not avail to ascribe all this to a dispensation

of Providence, for knowledge recognizes many of the laws by which Providence acts. Men demand equal justice from Providence, and they get it. The polluted stream kills. The polluted water-supply forms a net which Death casts in a city with grim certainty of its catch. Now that we know the reason of its deadliness, we demand no exception in its effects, for that were injustice and would hinder progress and encourage ignorance. But it is a pity, indeed, that thousands of innocent people must be killed every year to make an object-lesson for the ignorant politician. It is a pity, but it seems a necessity; for nothing short of a public calamity is able to turn the attention of many of our political rulers from their own wants to the wants of the public which supports them.

The death-rate of a community can be regulated, if proper control of affairs is acceded, with as much ease as a capitalist can raise or lower the value of a stock. The enforcement of hygienic regulations and the furnishing of a bountiful supply of pure water acts like magic on a town. They produce a reviving effect on the community that can be compared to nothing better than the result of opening a window in a badly ventilated church at about the middle of the sermon. By systematically disinfecting the city of Detroit, Dr. Wright caused scarlet fever and diphtheria to practically disappear. A disinfection of New Brunswick, N. J., with bromine, which I had carried on for two summers, was accompanied by the almost entire absence of *cholera infantum* in that city.

In view of the primary importance to the health, thrift and commercial prosperity of a community of a generous supply of pure water, I do not think that I exaggerate when I say that I consider the invention of the mechanical filtration of water by American engineers as among the most important ever made—in fact could there be an invention of greater importance?

ENGINE-ROOM CHAT.

By Col Loquial.

OUR Association was considering the question of having an entertainment for the purpose of raising money to put into a library of engineering, and each member was requested—which is the same thing as expected—to sell so many tickets. Some of the members refused point blank to sell any to their employers, on the ground that the latter were Jews; and this brought up the subject of Hebrews as employers—particularly in the manufacturing line. The result—almost the unanimous result—was that those who worked for Jews, or who had worked for them, would rather work for them than for Christians. They were close, they wanted money's worth, they looked out for their own interest, and would not submit to petty impositions; but *per contra* they were as willing to give their dollar for their dollar's worth as they were desirous of having their dollar's worth for their dollar. They appreciated in a commercial way the value of a good engineer as a money-saver, just as they did the value of a good buyer as another money-saver, or of a good salesman as a money-bringer; were as willing to pay a good price for good services as for a good article; were willing to pay as much for such service as the ruling price demanded; and in the matter of improvements might be called liberal. They took no special pride in having a handsomer engine or engine-room than any one else, or in having an engine or an engine-room handsome as a matter of beauty alone; but when it came to buying improvements or to making substitutions for the purpose of money saving they not only were liberal, but insisted upon being told of new and good things which would improve the working of the plant. Their attitude was that they hired their engineers just as they engaged their managers and superintendents; to render the best service that they knew how to render; to keep posted and to keep them posted as to improvements and progress in their special departments; and they considered that an engineer who failed to call the attention of his employer to things likely to increase the economy of his department, was not loyal. Attention being called to improvements and changes which might be desirable, the desirability was very carefully canvassed as a matter of dollars and cents, not of beauty nor of theoretical excellence; and if a device could be shown to be one which would save a dollar and a half by the expenditure of a dollar, that device was ordered to be put on as soon as it could be delivered and attached.

* * *

I know two engine-rooms, not far apart. They have the same style of engine, of practically the same horse power. One of these engines shines as though it had been burnished; the other looks dead and dull. On one of them every square inch, above and below, in front and behind, is rubbed bright each day. On the other, nothing is touched that can be left untouched. One of them reflects the light from every surface which was originally polished; the other is coated with a skin of oil and dust. One of them seems always to be wheezing and thumping; the other never seems to give any trouble. It is scarcely necessary to say that the one which gives trouble is the dull one, that the one which never does is the bright one.

Is there any reason for it?

There is.

The man who goes over and around and about his engine every day; whose eye rests upon every square inch of its surface, and whose hand touches every square inch, can keep it in order and does keep it in order better than he who simply squirts oil in or at the oil holes when he happens to think of it, or has his attention called to the necessity of oil by the squeak. A hot place is readily detected by him who goes often all over his engine, and can be

better attended to if discovered when a trifle warm than if allowed to get hotter and hotter until it squeals, or until the bearing seizes.

It is the same way with steam leaks and trifling cracks; the man who goes all over his engine once or more every day knows of them before they get serious, and attends to them at once. Leaks are incompatible with brightness. Brightness must be had, hence the leaks must be stopped at once when they are discovered.

There was a time in the history of the Philadelphia & Reading Railroad when in order to save time and money an edict was issued that there should be no more bright work on locomotives. Everything that could be black iron instead of bright iron or brass was made black. The main rod and side rods were painted; the brass straps on the jackets replaced by black iron, and so on all the way over the engines. The result was that before long instead of saving money by reason of the change, the Company began to lose. The engineer who took pride in his machine and who with a bunch of waste in hand went over every square inch with scrupulous care found out at once when there was any fire-box stay that leaked, any nut loose, any brace that rattled. When he was forbidden to make this trip for the purpose of beautifying his engine he ceased to make the trip at all; so there was no inspection because there was no trip. The engine got to going to the shop for repairs after shorter and shorter mileages; and after awhile the idea of having things rough and black was exploded and the company got back to the old idea of having things bright, so that it would be necessary for every part to be brought within the engineer's sight and touch.

* * *

It doesn't take very much of a philosopher to know how much more common hindsight is than foresight, and how much stronger it is. Nor does it tax the brain unduly to remark and fully appreciate the fact that the hindsight has very much more commercial value than the foresight. There are few lines of business in which this is more strongly the case than in engine tending. The old adage of Poor Richard or of some other homely philosopher that "a stitch in time saves nine" might sound rather inappropriate applied to a steam engine; but until there is one which expresses the same idea more strongly or even as strongly we shall have to suggest that it be written high upon the walls of every engine-room.

There are some engine runners who leave everything until the last moment. They belong to what the late John B. Gough called "three-handed people; two hands like other people, and a little behind hand." A bearing gets warm in the morning—it is let stay warm until noon. It may be slackened then; the intention is good, but the engineer may have something else to do; the main belt may have commenced to weave, and that may be the only time that he can get help to fix it and the only time that such fixing will not interfere with the working of the establishment. The bearing can run until shutting down time at six o'clock. When evening comes a manhole plate out in the boiler-room may have started to leak so badly—having been left unattended to for a few days—that it is necessary to blow down, and cut a new gasket, and do a lot of other things about the boiler, such as mending the covering where the leak has carried it away or made it liable to come off. This is an excuse for further postponement, so the bearing continues each day to get warmer and warmer, hotter and hotter, until the time comes when, having been forgotten and postponed, time and again, it seizes. Then, as the sailors express it, there is "the devil to pay and no pitch hot."

A stuffing-box commences to leak. There is not much of a jet that shows on every back stroke, and that doesn't waste much steam, and the Committee will be along very soon to arrange about the final details of the ball on Saturday evening. The gland can go; the gland does go; the leak gets bigger and bigger, and after a while the whole thing requires to be repacked, when a few turns with a spanner or a wrench would have stopped all the trouble—if done at once.

There is a knock in the cylinder. Probably water. That drip-pipe globe valve has its hand wheel knocked off and seems to be stuck on its seat somehow. It should have been attended to before, but there have been so many other things to think of that the valve has had to go. Now it cannot be opened. The steam chest being on the top there is no chance for water to get out. It will have to go. Water will have to be carried a little lower in the boiler to lessen the chance of its working over. This may be overdone, and the consequence be that the crown sheet gets burned or scale gets baked on so that the place will be burned or come down some day or other.

Or suppose that that risk is not taken, then some one opens out a steam hammer, or some other "steam chewer," and over comes a lot of water, stopping at the engine on the way from the boiler to the hammer, and it is lucky if the piston head goes instead of the cylinder head. In any case the mill or whatever the engine drives has to be stopped until a new piston can be made or ordered, and put in place.

* * *

There are some engines about which the slightest adjustment requires that the machine be stopped and taken about half down. There are others that may be adjusted not only without taking down other and important parts than the ones which are to be adjusted, but which can be attended to while running. Between these two classes there is a great difference at the end of the year in their economy of time to the establishment. It may make no difference whether the engineer has to devote ten minutes or fifty to do any particular thing; but if the engine has to be stopped and the whole mill or factory has to wait while the adjustment is taking place, there may be enough loss to make a big hole in the profits. Thus there may be engines which will save a little in coal bills but will lose ten times as much in profits. This matter should be looked out for. The engine builder can or will say very little on this score. Experience is the only teacher, and observation in other establishments and inquiry among engine owners and engine runners will sometimes enable a manufacturer to prevent being let in for $100 worth of lost time to save $10 worth of coal.

* * *

The question often arises as to how much service, other than that of merely starting and stopping the engine and seeing that it and the boiler are all right in every way, the engineer owes to his employer. No compact is ever made—or can be made—which will specify every trifling duty; and if such compact or contract were made there would be more kicking as to extra duties than if there were none.

There are some engineers who consider that their work begins at one certain hour and ends at another certain hour; that between those times of getting to work and quitting work all their time belongs to their employers for whatever purpose demanded, whether it be fixing belts or lining shafting or seeing to the unloading of new machinery.

There are many employers who take this view. More employers take it than employés.

Another set of employers, and some employés, think that the duty of the engine runner is not only to start and stop the engine and be about to see that all is right with it and the engine during regular hours and on regular working days, but to do out of these hours and days whatever may be demanded by the work of the establishment; that is, to work overhours and overtime without extra pay.

There is a third class of employés (I don't know that there are many employers) cherishing the idea that the work of the engine runner commences only at the hour designated, ending as soon after the evening whistle as things can be left safely; that there must be not one minute of extra time without extra pay; and not only this, that there should be no over service of any kind rendered, no matter whether the engineer can be spared from the engine-room or not. No shaft lining, no superintending the repairs of the stack, or of the steam-heating system; no anything except just attending strictly to the engine

and the boiler; doing that only during regular hours and on regular days.

There is not much trouble if both the employer and the engineer have the same ideas on this subject before they make their agreement; but trouble begins if the employer springs upon the employé some extra demand after he has been in service a while; or if the employé, after he has been working along quietly in a certain line, suddenly refuses to do anything more than he had been doing.

It is a good plan to have all these things understood beforehand, instead of "letting them right themselves." Things don't generally right themselves so well on the spur of the moment as they could be righted "first-off."

* * *

The average engine runner thinks that the average architect is a blathering idiot. The average architect thinks that the average engine runner is a dunderhead. Neither of these is entirely right, but in my experience I think that the architect stands more in need of a chat with the engineer than the latter does of any conferences with the man of plans and specifications. Go into nine engine-rooms out of ten where there has been an architect, and you find something wrong, which consultation with the engineer, or with some engineer, would have prevented without cost in the first case.

One case occurs to me now, where one of the most eminent architects in the country left an eight-inch iron column standing two feet out from the engine-room wall, thus making it necessary to place the feed pump and the fire pump in a dark and inconvenient corner. A very slight change in the symmetry of the plans would have left the engine-room free from any such encumbrances. The architect was spoken to about this before the cellar was begun, but was above taking any hints from anybody who ever wore overalls.

Another case comes to mind where the opening through which the main belt passes through the ceiling of the engine room is about two feet further back than it should be, and in consequence whenever the belt gets at all slack, it scrapes the edge of the opening, and it is necessary to take up a forty-eight-inch six-ply leather belt about twice as often as would otherwise be necessary, and to run it about twice as tight as is good for the bearings and for the belt itself—just because the architect would make no variation in the regularity of the terra cotta arching between the I beams which support the floor above.

In one of the finest buildings in New York the architect, sooner than have much of a projection into the business floors, has a flue of forty-eight inches by eight inches cross-section inside to take up the gases of combustion from a two hundred horse boiler. When we allow four inches all around for "dead space," that leaves us about forty inches by four for the passage of the gases.

A favorite trick of architects is to put the boiler room down in the back sub-cellar somewhere, to make it about ten times as difficult to get coal in and ashes out, as need be.

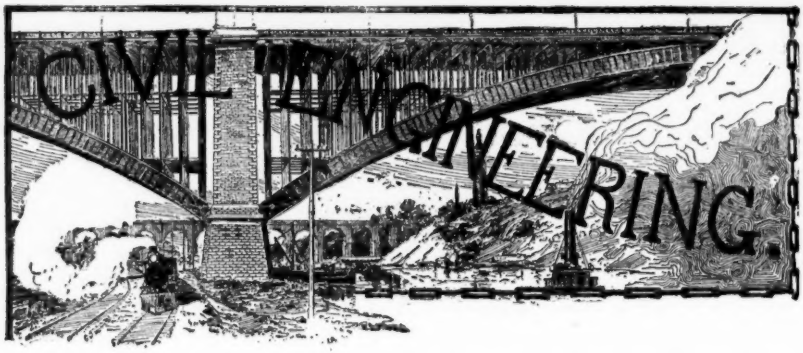
Another is to put the entrance to the boiler room at the far end of a blind alley, so that the only way that coal can be got in and ashes out is either to back in or to back out; no room being left to turn carts around.

Another specialty is to leave no places through which lines of pipe or shafting can be carried without breaking irregular holes through the walls. Arched openings, bricked up after being arched over, would enable additions or changes to be made at any time with the proverbial "neatness and dispatch."

A well-known architect specified three five-foot cylinder boilers in a sixteen foot boiler room. It is needless to state that the specifications were not carried out. The engineer thinks that the architect should have been buried deep where he would not be able to make any more fool specifications.

* * *

To sweep an engine-room or a shop without raising dust, don't sprinkle. Put down a layer of wet sawdust on one side, and sweep across the floor, then take it up.



THE Recent Collision in the Fourth Avenue Tunnel in New York, resulting in the immediate killing and burning of six people with more or less injury to others, not only emphasizes the fact that the murderous car-stove must go to make way for safer and more rational appliances for heating railway-cars, but also suggests that a provision against failure at the "*human end*" of the block signal system, as the New York *Sun* aptly expresses it, is needed to perfect that system. It appears that no matter with what automatic certainty the mechanism of the system may act, an element of uncertainty is still left in the mental, moral and even physical constitution of those who operate it and the engineers and trainmen who are supposed to be guided by its indications. Mr. Depew is quoted as saying "Get as perfect a system as you like, accidents may happen which seem inexplicable. How do you account for this? An engineer may have been running a locomotive twenty years without an accident, and may be considered as reliable as you like. But some day, as he drives along with his mind intensely set on noting every signal and sign of danger, he will do the very opposite of what he intended, and a great calamity is the result. It may be that the engineer saw a red signal, but in his desperation to avoid it he rushed headlong into the midst of the danger. To say that a man's mind is unbalanced seems to explain it only partly." This being admitted by one of Mr. Depew's experience in railroading, and one so capable of forming trustworthy opinions as he, the logical conclusion from the premises is, that the "*human end*" must be supplemented with automatic mechanism that renders it impossible for a locomotive to enter a block when the danger signal is set. As it now is, a train entering a block, automatically sets the danger signal, and as it is termed, "locks that block" against the entrance of the next approaching train so that it cannot pass without disregard of the signal until the train already in the block has passed out. Now it would seem that the thing to be locked is the train, which through the fatuity of its engineer, seeks to enter the closed block. If a train may automatically lock the signals on entering a block, what mechanical obstacle prevents the locking of an approaching train? That is to say, what is there to hinder an automatic train of mechanism taking its initial motion from some device connected with the signal system, from reversing an engine and applying the air brakes the moment the train passes a point fixed upon as the limit beyond which it cannot pass without danger? Stop-motions in other kinds of machinery are numerous. The breakage of a single roving in a drawing frame for cotton, tilts a tiny lever which through intermediate mechanism runs the driving belt on to the loose pulley and stops the ponderous machine. It is not long since an automatic stop for trains was tried and successfully worked on a road in New England, the brakes being applied by the engagement of a small lever projecting laterally from the pilot with a stop previously fastened to the track, the purpose of the inventor being to provide a means of positively stopping a train on its approach to a danger-

ous position, such as a stalled train, broken bridge, etc. It is not much farther to the combination of such stops with a system of block-signals. This is a hint that ought to set some inventive mind at work upon the problem of not superseding, but supplementing the "*human end*" of the block signal system. There is a law in New York State prohibiting car-stoves. The New York, New Haven and Hartford road have contested this prohibition in the courts, with the result, that though the corporation has been able to delay substituting for them an admittedly safe and efficient system of heating, the courts so far have rendered decisions adverse to the contention of the company. It would seem, that should the higher courts sustain the rulings of lower tribunals, the charge of criminal negligence upon which the coroner has based his action in issuing warrants for the officers of the railway, might place these gentlemen in a very unpleasant position. The inquest conducted by the coroner was very thorough, and the more than ordinary ability of the jury impanelled by him is generally conceded. The wisdom of the enactment was demonstrated in a long series of similar catastrophes prior to its becoming a law, but this is not a solitary instance wherein a corporation has set its own real or fancied interests before those of the public it was created to serve.

Compressed Air as Motive Power has been proposed for the city of Dresden by Dr. R. Proell. Steam boilers are prohibited in Dresden, and this scheme has been designed as a substitute. Probably the most novel features of the scheme, says London *Engineering*, consist in the motors, which it is intended to erect for the utilization of the compressed air. Heating the air during expansion, and at the same time injecting a water spray, are the leading points. For medium powers of 4 horse power and upward, the author proposes to use the "Doerfel-Proell" engine, of which a considerable number are already in regular use with steam, giving very economical results at from 200 to 300 revolutions. This motor is combined with a coil boiler, in which the compressed air is heated before it enters the motor, and during the heating process a small amount of water enters the coil from an overhead reservoir, while the exhaust air is used for accelerating the draught, thus establishing a self-regulating arrangement. For small powers of from ¼ horse power, a new compound single-acting engine has been designed, somewhat of the pattern of the numerous box engines, the two cylinders being arranged on one centre line vertically above each other, and the pistons attached to the same crank passing between the two. In these little motors a gas burner is provided under the bottom of the low-pressure cylinder to heat the air as it expands in the latter. In large engines, however, such as would be necessary to supply electric light for a district, the air-heating appliance would require considerable heating surface and to obviate this combined gas and air engines have been designed in which the heat of the gas explosion is immediately utilized to warm the compressed air used as motive power in the air cylinder. The two cylinders are arranged horizontally, tandem fashion, the air cylinder nearest the crankshaft. The compressed air enters the jacket of the gas cylinder (which latter is of the two-cycle Benz type), cools this and enters the working cylinder ready heated. This heating is of considerable importance, and when completely carried out, the author asserts that air motors can be worked as economically as any other method of power transmission, or producing steam power on a moderate scale.

The Ravages of Teredo Navalis, or as it is commonly called the ship-worm, appear to be more severe in Northwestern waters than almost any other part of the world. The *Commercial News*, Cal., states that a pile lying in the water only thirty days at Seattle was destroyed by this pest before it was used, a section one foot in diameter having by actual count 212 holes bored in it. Natural or artificial stone or cement appear to be the only materials available for permanent submarine structures, anywhere, and if, in New York Harbor, ship-worms were as numerous and active as the above statement shows them

to be in Puget Sound, our hosts of wooden piles would soon have to be replaced by masonry.

A Giant Dam for diverting the course of the river Periar in India, for irrigating the Madura district forms the subject of an interesting article by John S. Chandler in the *Scientific American*. This dam is to be 150 feet high, 60 feet wide at the base, and 15 feet at the top, and will be composed of hollow walls of masonry, filled in with cement. The water will be set back by the dam sufficiently to form a lake ten miles long, and seven miles from the dam the water will also set into and fill a deep valley inclosed by a rocky wall, an outlet from which will be obtained by tunnelling 5700 feet through the rock. Another large channel 38 miles long is under construction to carry the water to the northern part of the Madura district, and bridges will have to be constructed at points of the stream now fordable but which when the dam is completed will no longer be so. Mr. Chandler eloquently closes his article as follows:

"Cyrus turned the waters of Babylon from the Euphrates channel to conquer human foes. The British Government is turning this river to conquer famine and starvation and save humanity."

The cost of these works is expected to reach $4,000,000.

A New System of Ventilating Railway Tunnels has been invented by M. Pochet, a French Government Engineer, and will be applied on the Metropolitan Railway in Paris. Prominent and vital features of this system are, first, the formation of a continuous smoke-chamber extending the whole length of the tunnel for the reception of steam and smoke, the chamber being formed in the top of the arch by an overhead horizontal flat partition, cutting off a segment of the space in the crown of the arch and communicating once in every half-mile with a ventilating chimney in which is a suction ventilator. This smoke chamber is centrally divided by a vertical partition extending its whole length, and in the bottom of each of the flues so formed, is a longitudinal continuous slot closed by balance flap-valves and extending directly over the upper ends of the smoke stacks. Second, the smoke-stacks of the locomotives are flattened on opposite sides to make their openings oblong and discharge their contents into and through the slots and flap valves and directly into the smoke-chamber, which is thus made to receive all the steam and smoke, leaving the air perfectly pure below the horizontal position.

The Life of Railway Ties in actual use has been investigated by the Forestry Division of the U. S. Agricultural Department, and from reports obtained from 283 different railroad companies, the following table has been compiled, the figures indicating years:

Kind.	Range.	Average.
Conifers:		
Redwood	8–15	11–12
Bald cypress	4–12	8–10
Red cedar	....	10
Tamarack	4–12	7–8
White cedar	4–10	7
Pine, long leaf	5–10	6–7
Pine, red and white	4– 8	6
Pine, bull (California)	6– 9	6–7
Pine, bull (Colorado)	3– 6	5
Hemlock	2– 8	4–6
Spruce	3– 7	5
Broad-leaved trees:		
White oaks	3–12	7–8
Chestnut	4–12	7–8
Honey locust	....	10
Coffee tree	7–10	....
Cherry, black walnut, locust, sassafras	6–10	7
Mulberry	5– 6	6
*Mesquite	....	....
Elm	4– 9	6–7
Black oaks	2– 7	4–5
Ash, beach, maple	2– 7	4

This is, of course, for wood not subjected to antiseptic treatment.

The Magnitude of Our Inland Lake Commerce is is exhibited in returns of the census of 1890. About 75 per cent. of this traffic is in coal, iron and lumber and nearly 15 per cent. in corn, wheat, flour, etc., leaving only about 10 per cent. for miscellaneous traffic including general merchandise. The aggregate tonnage for the season of 1889, was 27,460,260, carried an average distance of 566 miles, not including the Canadian coasting trade. This is a fraction less than 23 per cent. of the total mile tonnage of the U. S. railways.

Receipts and shipments in and from the

* The life of mesquite, if sound, is claimed to be interminable.

following ports for 1890, were as named below, showing an aggregate increase of 1,500,000 tons since the season of 1889:

	Receipts.	Shipments.
Chicago	5,069,973	2,914,065
Buffalo	4,046,144	2,683,993
Cleveland	2,737,708	883,862
Ashtabula	2,205,595	489,085
Milwaukee	1,584,251	351,554
Tonawanda	1,046,895	None.
Toledo	506,351	930,640
Erie	773,040	498,958
Superior	875,692	304,605
Duluth	683,162	430,886
Detroit	615,750	148,803
Oswego	402,847	288,271
Ogdensburg	470,044	192,860
Lorain	346,899	273,874
Sandusky	305,029	297,574
Ashland	487,350	1,759.884

An interesting feature of these statistics is, that the shipments exceeded receipts in two only of the ports named, to wit, *Toledo* and *Ashland*. These figures will probably much exceed previous conceptions in the minds of those unfamiliar with the growth of commerce upon these waterways.

The Manufacture of Weather, that is to say, cold weather, is now regularly practised in the large breweries, abattoirs and packing houses, by the use of ice machines. The attempt to manufacture rainy weather by violent explosions in the higher atmospheric regions is to follow. Statistics having shown that heavy rainfalls have followed closely upon the occurrence of battles, bombardments and violent explosions or to say the least, having been thought to show this, Congress at its last session made special appropriations for experiments intended to influence by this method the amount of rain-fall upon arid regions of the West. These experiments are to be conducted by Professor Myers, who will begin them by the use of 100 balloons of different sizes, carrying and floated by explosive mixtures of gases to be exploded in the upper air. The requisite gas plant for the generation of the oxygen and hydrogen already exists on a large scale at the balloon farm at Frankfort, N. Y., where is situated the extensive balloon works of Professor Myers. The generation of hydrogen for ballooning is a specialty with which he has probably had a larger experience than any other living person. To reduce the expense, paper will be substituted for the usual textile fabrics in the balloon, a special quality of which will be manufactured for the purpose from the redeemed greenback paper pulp, which suitably varnished by the machinery used at his works, Professor Myers believes will answer most of the purposes required. The explosions will be effected at various heights and under varying conditions through the medium of galvanic batteries and an electric cable, which will serve both to retain the balloons captive, and to conduct the electric spark to the explosive compound. Experiments at the balloon farm will be conducted for testing the working of the entire plant, after which further experiments will be made at or near Washington, D. C. After this the experiments will be transferred to the dry regions of Texas, Colorado, etc.

The New Steel Cruiser No. 13, to be built under the Appropriation Act approved March 2, 1891, is to be promptly constructed. Proposals to be opened June 1, next, have already been invited by the Navy Department. All material to be used in the construction of the new vessel, including engines, boilers, and machinery, are required to be of domestic manufacture. The Government will provide all armor, armor bolts and their accessories, excepting such as may be required for the protective deck, but the contractor will be required to put them in place. The vessel must also develop on her trial trip in the open sea a speed of not less than 21 knots per hour for four consecutive hours, or the contractor will be subject to a penalty of $25,000 for each quarter knot deficiency. A premium of $50,000, however, is provided for each quarter knot developed in excess of 21 knots. Proposals are invited under plans and specifications provided by the department, and also under plans and specifications provided by the bidder.

The Protective Treatment of Timber was the subject of an interesting and instructive lecture by Mr. Octave Chanute, recently delivered to the students of the Rensalaer Polytechnic Institute in Troy, N. Y. In this lecture Mr. Chanute states that, although the price of railway ties is lower now than it was in 1882, yet, as twice

the quantity of timber produced by our annual forest growth is annually consumed, the price of timber is sure to advance, and the necessity of economy is sure to be felt more strongly than has hitherto been the case. Economical results reached in France by antiseptic treatment have been a net saving of $3,000,000 per annum on the railroads of that country. He further estimates the easily attainable economy by antiseptic treatment of ties on U. S. railways at the enormous figure of $8,008,926. Mr. Chanute expressed the opinion that there is little likelihood that any better preservative substance for the antiseptic treatment of wood than is now known will be discovered, the poisonous mineral salts, such as copper sulphate, and creosote or substances of the phenol series now being the means at the disposal of engineers for this purpose.

Two New Spanish Cruisers, each of 9000 tons displacement, 2000 indicated horse-power, and each to have a speed of 22 knots per hour, are to be added to the Spanish navy as soon as they can be constructed. These vessels will form part of the new ships for which the legislature voted $10,000,000 two years ago, and of which six vessels are already in the hands of contractors in the dockyards and at Bilboa.

The New German Steamer built for the Hamburg Line by the Vulcan Company at Stettin, is expected to be in commission before the issue of this number of ENGINEERING. She is 520′ long, 58′ wide and 40′ deep. Her displacement is 12,000 tons. Her engines are built to develop 16,000 horse-power. Her decks, five in number, are of steel and teak-wood. She has duplicate engines and boilers, separated by a longitudinal bulk-head so that one set being crippled from any cause, the other can be used. She has nine double-ender boilers, each 17′, 3″ long, and having a diameter 15′, 4″. The total heating surface is 35,000 square feet. The total grate area is 1220 square feet. The working pressure is 150 pounds per square inch, and the engines are triple expansion. The boilers are set in threes, each set in a water-tight compartment.

The Monte Generoso Railway is perhaps one of the most remarkable as it is the newest of the Swiss mountain railways, which, according to the *London Graphic*, will soon provide nearly every mountain with its own private railway. This mountain, sometimes called the Rigi of Italian Switzerland, rises 5560 feet from the level of the sea, and combines the charms of an Italian landscape with the grandeur of the Alps. The railway, a cog wheel on Abt's system, was completed in May, 1889. Starting from the village of Capolago, at the southern end of Lake Lugano, the line rises with a steep ascent for about two miles, until it reaches a perpendicular precipice. This is pierced by a loop tunnel which emerges at the first station, San Nicholao. Two smaller tunnels are traversed ere the train arrives at the middle station of Bellavista, where is situated, on a magnificent mountain terrace, the Monte Generoso Hotel. There are one or two more stations to pass through before the engine with a last strenuous effort, climbs the steep slope just before the summit, known as the Vetta. From the top, about ten minutes' walk from the terminus, a grand view is obtainable over Italy, Switzerland and the Tyrol.

Advantages of Oil as Fuel as compared with coal in a number of New England plants where oil has been used, appear from reports to consist more in the cleanliness and convenience of such fuel, than in any saving in cost of fuel. An average cost of 6-10 of a cent per h. p. per hour, is about what has been reached, which compared with coal at $2.50 per ton of 2000 lbs. shows the latter to be more economical, estimating the evaporation as 10 lbs. of water per hour per lb. of coal, and 30 lbs. of water per hour evaporated as the standard for one indicated h. p. developed.

Liquid Fuel for Locomotives is asserted to have proved very successful on the Great Eastern Railway in England. The liquid used is tar with a certain admixture of green oil, and it is not used by itself, but as an auxiliary to coal, being introduced as needed to the furnace through a so-called injector. Over a dozen engines have been supplied with this apparatus

and are using this mixed fuel. It is asserted in the English papers that the relative cost of the combined material is rather less than coal at the present prices of both, and that the value of the "injector" is seen to especial advantage on gradients, when steam can be got up instantly by simply touching a tap close to the driver.

Queer Engineering that must be on the New York Central and Hudson River R. R. which loads the roof of an old round-house with the additional weight of a number of large iron smoke-pipes leading from the stalls to a common chimney, and to such an extent that the stress of the first moderately strong wind blowing thereafter drives in the roof. This accident occurred on the 14th of March at the round house of this company situated west of Lexington Avenue, between 45th and 46th Streets, New York City. About 70 or 80 square feet were thus crushed in. Fortunately the fall occurred so early in the morning that no one was in the building and there was therefore no injury to life or limb.

An important test of Armor Plates is to be carried out this spring by the U. S. Navy Department, at the ordnance proving grounds on the Potomac. Congress having authorized the Navy Department to use $100,000 for experiments with armor plating, the experiments under this appropriation will begin with three 3-inch plates 6'x8' in dimensions, one of steel, a second of nickel alloy, and a third of nickel alloy which has undergone the Harvey decarbonizing process, this alloy in plates already tested having given excellent results. Each plate will be tested by 20 shots from a high power 40 calibre 6-inch gun, at a range not exceeding 30 feet.

The Paving in New York City amounted on June 30, 1890, to 359 miles in length of streets, the variety and quantity of each kind being as follows: Specification granite 2,225,811 sq. yards; 673,402 sq. yds. block granite; 1,248,529 sq. yds. specification trap; 3,045,214 sq. yds. Belgian blocks; 101,643 sq. yds. cobblestone; 71,190 sq. yds. asphalt; 515 sq. yds. wood; 2964 sq. yds. Russ; 908,354 sq. yds. macadam. The latter as exemplified in Lenox Avenue, and in the upper part of Seventh Avenue, now a well built up quarter of the city, though well adapted for pleasure driving, is loudly protested against by the local residents, as in wet weather they are pools of mud, and in the windy, dry weather the dust from them is well-nigh intolerable. They are little better in these respects than average country roads.

The Manufacture of Car-Wheels has been greatly improved during the last decade. A system of comparative tests has been adopted by the New York Car-Wheel Works at Buffalo. These include two tests for chill, a test for transverse strength, one for torsional strength, a test for hardness of chill, and another for shrinkage and fluidity of metal. Besides the above, daily tests are made for the chemical determination of carbon, sulphur and phosphorus in the metal used, and one wheel out of every 25 made is subjected to the full "Pennsylvania" test on Pennsylvania testing apparatus. Best results have been obtained from wheels ground true, or, as they are technically termed, machined wheels. By their use brake sliding is said to be almost completely obviated and a very marked increase in mileage is attained.

The Painting of the Great Forth Bridge will give ordinary people about as good an idea of the real magnitude of this wonderful piece of engineering as they could otherwise possibly gain, when the quantities of materials used in the job are stated: Machinery and illuminating oils, 980,072 gallons; paint oils, 35,527 gallons; paint, 250 tons. It is computed that the quantity of oil used would have been sufficient to float one of Her Majesty's first-class cruisers, and that there was sufficient paint employed to cover 1100 acres, or nearly two square miles of surface.

Vulcanized Timber used with iron for dados, architraves, and mouldings and the adoption of sensible ideas in factory construction would, in the opinion of Mr. Edward Atkinson, as expressed before the Boston Architectural Club, save $50,000,000 per annum in this country through the prevention of fires and limitation of damages therefrom.

THE New Bronze Doors for Trinity Church in New York City, which are to be made in accordance with the provisions of the late Mr. John Jacob Astor's will, were competed for by a number of sculptors, the competition having been placed in charge of Mr. Richard M. Hunt, an eminent architect, whose fitness to decide upon the merits of the designs will not be questioned. His awards for designs are as follows: The main doors were awarded to Carl Bitter, a young artist of great promise. This award is specially noticeable as Mr. Bitter is only 26 years of age, and his competition was against much older and more experienced artists, there being six competitors in all. J. Massey Rhind and C. H. Nichaus were respectively awarded commissions for the side doors. The general architectural design for the main doors, as fixed upon by Mr. Hunt, is as follows: The pediment formed by the Gothic arch over the doors will be fitted with New Jersey sandstone, supported by a column of the same stone, which will separate the two doors. It will be Bitter's work to execute the carving on this stone, as well as to design the bronze panels. In the upper part of the pediment, carved in the stone, will be a full length figure of God, with angels on either side in adoration. Just below this will be twelve niches in the stone, in which will stand probably the figures of the twelve apostles, filling out the rest of the arch. In each of the two bronze doors will be three panels, each 3 feet wide by 2½ feet high. Upon the designs for these panels Bitter will spend the most of his time, for they will be the principal features of the doors. On the side of each panel there will be a figure representing a Biblical character. It is not definitely known what the subjects for all the panels will be. The first will represent the expulsion from Eden, the subject chosen for the competition, and the second will be the killing of Abel by Cain. The Rev. Dr. Morgan Dix, the rector of Trinity, will instruct the sculptors as to the religious treatment of the subjects that their designs may harmonize with the tenets of the Protestant Episcopal Church. The side doors are intended to harmonize with the main doors. Each will be fitted with arches of red sandstone designed by Mr. Hunt like the main door, with a full-length carved figure on each side, and will be divided into six sections or panels, each containing a figure in bas-relief. Both the design of Mr. Rhind and that of Mr. Nichaus upon which the competition was based are admirable and the worthy treatment of the new doors is assured by the selection of these artists. The artists are allowed one year to complete their work.

The New Hotel Waldorf, projected by Mr. Astor and designed by Mr. Hardenbergh, is evidently going to eclipse any hotel yet erected in New York. In the first place the site—that of the old residence of John Jacob Astor, on Fifth Avenue, is one of the best hotel sites in the city. The two lower stories are to be of the reddish tinted Maynard stone. Above these the colors will be terra cotta and cream treated with artistic skill. The height is to reach twelve stories, and these will be surmounted by a conical roof with ornamental chimneys, towers and turrets. Numerous balconies, on both the 250 feet frontage on Thirty-third street and the 100 feet Fifth Avenue front, will afford means for a grand scheme of floral decoration which is to extend from the turrets to the

basement. At the rear of the building there is to be a magnificent open-air garden which can be covered with glass in winter, and numerous hanging gardens are to add to this beautiful floral effect. Besides this there are to be conservatories in the basement. In addition to the public rooms, which besides those common to hotels will include a ball-room in old-rose and lavender, a bridal room in pale blue, and Turkish salons, there will be 500 private rooms for guests. The large ball-room will accommodate 250 couples. A grand corridor will extend from the office through the entire building. Every bath-room in the building is to be independently ventilated. The hotel will have plants for electric illumination and for artificial refrigeration installed in the basement. The completion of this elegant building is projected for the fall of 1892.

The Proposed Roof-Garden on the Reservoir at Forty-Second Street in New York City has provoked a sharp newspaper controversy as respects its practicability from a sanitary point of view, in which the experts of the Board of Health and sundry physicians who have sided with them are getting rather the worst of it. These experts took the ground that covering in the reservoir would produce an unsanitary condition in the water, and predicted no end of evil if the project should be carried out. The New York *World* took up the argument in favor of the project and in opposition to the opinions of the gentlemen referred to, proceeded to show from testimony of English engineers that in London the law imperatively requires that all public reservoirs shall be covered. It cites the testimony of continental authorities to show that this is also the invariable rule in France and Germany. In commenting upon this the Brooklyn *Eagle* näively remarks that "the sanitary reason advanced by the European authorities to justify the covering of all the reservoirs seem to the lay mind almost as convincing and conclusive as those urged by the New York Board of Health against the covering of the Forty-Second Street reservoir." Mr. W. B. Bryan, Chief Engineer of the East London Water-works, is reported in the *World* as saying that "In large and populous cities it is not safe to let the water stand in open reservoirs and then draw it directly into the service mains. In London covered reservoirs are doubly necessary, as our water is very hard, even after careful filtration. If exposed to the air it soon begins to vegetate. Too much care cannot be taken with the public drinking water. Covered reservoirs are certainly a great protection against contamination." This view is not only corroborated by other eminent hydraulic engineers, but accords with common sense.

An Interesting Building has been erected on the summit of Mont Blanc, by Mr. J. Vallot of the French Alpine Club. It is to be used as an observatory and a refuge. The plans having been carefully designed with reference to the effects of the high winds that assail this peak, the structure was built in the valley of Chamounix, then taken apart (the timbers, etc., being carefully numbered) and transported piecemeal to the top of the mountain. The pieces were carried up on the backs of 100 guides, there being 111 loads to transport. The transportation of the building was completed on the 31st of last July, and 90 packages of scientific instruments were conveyed to it by the guides in the same manner as the transportation of the building was effected. Five carpenters then began to erect the building, but after working four days were obliged by fatigue and unfavorable weather to suspend operations, although the house was yet unfinished. On the 31st of August they reascended the mountain, finished the building, put up lightning rods, and hoisted colors over the observatory. The building is divided into two apartments, one designed for the use of travellers and the other for scientific observers. The latter room is a private compartment. The public room is supplied with all the conveniences needed by the tired tourist. Nine beds are placed in the room, and a supply of provisions and of oil for light and fuel is always kept on hand. The observatory, which is said to be the highest in the world, is 14,350 feet above the sea level.

It contains automatic registering devices and the most approved appliances for making scientific observations in high elevations.

The Effect of Roofs Upon the Draft of Chimneys is too little considered by architects. The flat roof offers no resistance to the passage of air, but as the pitch is increased, the current is more and more disturbed, until with a high-pitched and many-gabled roof it is broken into innumerable eddies, some of which are sure to curl down and force the smoke and gases in the flue into the rooms below. Chimneys on such roofs should be built higher than ordinarily.

The Proctor Tower at the Columbian Exposition in Chicago, will be constructed under the supervision of Messrs. Holabird & Roche, architects of Chicago, assisted by Mr. C. T. Purdy, M. E., the designs for it having been accepted. It will be a graceful structure 1100 feet high, surmounted by a tall flagstaff. Ten elevators will carry passengers to the top. Four of these will run to the first landing, 200 feet above the ground; two will run to the second landing, 400 feet above the ground, stopping at the first landing; while two others will run up without stop to the second landing; and from the second and third landings two will shoot up into the dome, 1000 feet above the ground. The capacity of these elevators is 8000 people per hour one way, or 16,000 people an hour up and down. The structure will be brilliantly lighted by electricity, which will also furnish the power for the hydraulic elevator pumps.

Plans for the Columbian Exhibition Government Buildings, completed in Washington, comprise buildings which will be nearly square, will cover nearly 150,000 square feet, and have a main entrance and ornamented arcade resembling the Arc de Triomphe at Paris. In the middle a handsome, pagoda-like tower will rise, beneath which will be a great rotunda. The building will cost $400,000, and $1,000,000 will be spent on the exhibition and in its annexes. The Government buildings at the Centennial cost only $80.000.

The New Masonic Building in Chicago, is to emulate in respect of height the famous tower of Babel. Twenty stories high with a frontage of 170 feet, a depth of 114 feet, a roof 300 feet above the street level, 18 elevators, capable of transporting 40,000 people daily, an entrance 28 feet wide and 42 feet high, a rotunda 3700 square feet in plan, a pavilion roof garden, all these are features of the building which is now in process of erection. With her 18 story and 20 story buildings, the Auditorium and the Proctor Tower, Chicago will eclipse all other cities on the continent in the matter of huge and tall buildings.

A Board of Examiners for Plumbers has been established in Detroit, and no doubt such boards in all our towns and cities would meet the warm approval of the better class of architects, who find in defective plumbing one of their principal annoyances. It is stated that so much ignorance was developed by the examinations of the Detroit board, that it was obliged to temporarily lower its standard of qualification for licenses, and to adopt a system of two classes of licenses, one permitting the performance of any kind of work, and the other limited to putting in service pipes and making connections with yard hydrants and kitchen faucets. The standard of first-class qualification will also be raised as soon as this becomes practicable, and those licensed to do sanitary plumbing will be obliged to undergo still more rigid examination.

Plans for the World's Fair Buildings at Chicago, have been prepared by Richard M. Hunt of New York, Geo. B. Post of New York, McKim, Meade & White of New York, Peabody & Stearns of Boston, Van Brunt & Howe of Kansas City, and by local architects of Chicago. Mr. Post has designed a building for the exposition of the industrial and liberal arts. Mr. Hunt has designed the administration building. Mr. McKim has supplied a design for the agricultural building. Peabody & Stearns present drawings for the machinery hall. Van Brunt & Howe have designed a building for electrical exhibits. S. S. Beaman of Chicago has in hand the building for mining exhibits. The horticultural building is the subject of a design

by W. L. B. Jenny of Chicago. The fish and fisheries building has been designed by Mr. Henry Ives Cobb of Chicago. Burling & Whitehouse of Chicago, have prepared the drawings for the grand entrances and triumphal arches. All of these architects are eminent in the profession, and, according to the Chicago *Herald*, from which the above is abstracted, their plans are likely to stand, unless the architects come into collision with the Board of Control. The plans have all been carefully scrutinized by Mr. Richard M. Hunt, President of the Board of Architects, and, it is understood, are approved by the entire board.

The Best Preservatives of Iron, according to Professor Lewes, are tar and its derivatives, such as pitch, black varnish, asphalt and mineral waxes, which are recommended. This, however, is conditioned upon the removal of the small quantities of acid and ammonia salts which frequently occur in tar and tar products. If in addition any of the class of substances mentioned is applied hot to warm iron, the bituminous and asphaltic substances form on the surface of iron an enamel which is not, like other coatings, microscopically porous, and therefore pervious to water. Spirit or naphtha varnishes are condemned by Professor Lewes; varnishes to which a body has been given by some pigment, generally a metallic oxide, are preferable to the last class, if the solvent used is not too rapid in its evaporation, and if care has been taken to select substances which do not themselves act injuriously upon iron, or upon the gums or resins that are to bind them together.

Bad Floors in Buildings are unfortunately too common, and are, according to the *N. W. Builder and Decorator*, attributable to the neglect of both architects and carpenters. As perhaps three fourths of all floors laid are of yellow pine, a material that gives better satisfaction than even the higher priced hard woods, and as every architect and every carpenter knows how to obtain an almost perfect floor with this material, where does the negligence manifest itself? In the selection or acceptance of the material. Every board should have a straight or "comb" grain, and if the log is properly sawed every board will have such a grain, just as quarter sawing produces a grain of a peculiar kind and beauty, but very few mills care to take the trouble to saw in this manner, and they will not as long as they can sell any kind of stuff for high grade flooring.

Testing Paving Material in the Paris Testing Laboratory is systematically carried out as described in *Le Genie Civil*: An official of the department registers the weight at the station of departure and a Paris official attaches a lead seal to each sack on its arrival. The cost of inspection is partly borne by the cement makers, and the Passy company pays $300 annually and the Portland company $400 for this service. The details of tests are published quarterly, and in it a list of authorized makers is given. Cements are now being tested after being in stock three or four years, and with hot water.

Water-proof Painting for Iron Work may be tested as follows: Take a small piece of iron and paint it thoroughly with the paint to be tested. After drying, place it on a glass plate and wet it with water. Then place a watch crystal or bell glass over it, making the edges tight with gum or varnish. If the paint is pervious to water, the water will gradually disappear, being decomposed by the iron, the oxygen uniting with the iron to form rust. If the paint is absolutely water-proof the water will remain in the chamber indefinitely. It is said that a pure asphaltum paint is the only one which will stand this test.

German Experiments with Building Stones (21 kinds of natural stone and 41 kinds of artificial stone having been tested and the results communicated to the Society of Chemical Industry) indicate that comparatively few of the limestones or sandstones can resist the effects of alternate freezing and thawing. Only 6 of the samples of natural stone and 3 of the artificial were found to endure the test of freezing and thawing 25 times. The statement indicates a large percentage of failure. The degree of failure in each sample, not stated, is a needed supplement to this brief summary.

THE Elevated Roads of New York are usually compared with the London underground railways, as though the latter afforded the only means of steam transportation at the disposal of Londoners. In certain districts it is; but it must also be borne in mind that there are fourteen railway termini in London, all of which accommodate suburban as well as main-line traffic. It is possible to live in various suburban quarters nine or ten miles out of London, almost in the open country, and be landed in the heart of the city every day in less than twenty minutes. The underground road therefore only forms a single item in the transit facilities of London, and a very unpleasant item it is. The service is not any too fast, and owing to difficulties of providing efficient ventilation the atmosphere is in many sections deplorable. Londoners are no more partial to this sort of travel than Americans, and the company is frequently urged to adopt electric traction. This has not yet been attempted, but nevertheless London has been the first city to demonstrate that electricity is capable of replacing steam as a motive power for railways operated on a large scale.

No electrical engineer who has had any experience with electric railways in this country ever felt any doubt that the electric motor was as competent to draw a train of cars at a high speed as to propel a single car at a comparatively low speed; and many of them would have been only too glad to accept a contract to provide New York, or any other city, with just as perfect a system of underground electric transit as has recently been inaugurated in London.

The City and South London Railway was organized to provide quicker transit for some of the south-western suburbs of the metropolis. The City terminus of the line is at King William Street, within a short walk of the Bank of England, the Royal Exchange and the Mansion House—in other words in the very heart of the business district. The further terminus is at Stockwell, a residential district just north of the famous Clapham Junction. The total length of the line is about six and one-half miles. Applying this line to New York City, it would have one terminus say at Rector Street, and the other somewhere in the nineties. The tracks are carried through iron tubular tunnels each ten feet six inches in diameter, the up and down track running in separate tunnels. These iron tubes have been driven through the London clay at a depth of sixty feet below the surface. In this manner the foundations of buildings and the ramifications of sewers and other underground pipes and conduits have not been interfered with, while so efficient is the system by which the tunneling is effected that an underground river (previously known to exist in London, although its exact course was not a matter of definite knowledge) which was found to run directly across the line of boring proved to be no serious obstacle to the progress of the work. The river was dammed back by air pressure and the tunnels pursued their way serenely. The two tunnels are entirely independent of each other, so much so that although for the greater part of the way they run side by side, in some places they are placed one above the other. The entire equipment of the road is electrical. A large generating plant has been established at Stockwell, from which current is furnished for motive power and lighting. The trains consist of three long cars drawn by an electric locomotive. These locomotives

weigh ten tons each; all gearing is dispensed with, the armatures of the motors being attached directly to the axles of the driving wheels of the locomotives. In this arrangement alone a great advantage is gained, but it is only possible where high speeds are allowable. Each locomotive has two electric motors, the current being obtained from an insulated conductor of steel laid between the track rails, the latter forming the return half of the circuit. The cars are lighted electrically, although curiously enough the stations have to depend upon gas for their illumination. The general arrangements of the road are quite on the American plan. A fixed fare is charged for any distance and no tickets are issued, passengers paying their money and walking through a turnstile. The cars are of uniform class, and passengers can pass from one car to another, a conductor being stationed on the platforms between each car to open and close the gates and doors. The road has been in operation for some months with perfect success. Trains are run on a headway of five minutes at an average speed of twenty-five miles an hour, and so quickly has the new line found favor with the travelling public, that the headway will be lessened, and the number of trains increased as soon as the necessary arrangements can be made.

An American Electrical Engineer who has done pioneer work in the development of electric traction in this country, inspected the works and equipment of the London electric underground shortly before the line was opened for traffic. He states that the work is excellent in every respect, but is of the opinion that he could do as well if not better. It is earnestly to be hoped that he will soon have the opportunity to expend his energies in such a direction in New York City. London has had the opportunity of showing what electricity can do, and since this demonstration the general public is showing signs of emphatically supporting the electrical profession in its opinion that in electric traction will be found the true solution of New York's rapid transit quandary.

An Underground Electric Railway combines the advantages of both parts of the scheme while the disadvantages of both are nullified. An underground road can be constructed quickly without damaging or defacing property, and is secure from interruptions and accidents or delays to which surface or elevated roads are liable, while higher speed can be made. Electric power is more economical than steam; safer, cleaner and healthier. The principal disadvantage of a steam underground road is the pollution of the atmosphere by smoke and fumes from the locomotives. The objection to electric traction in cities is levelled at the trolley wire and its supports. In an electric underground road both these objections obviously disappear at once. No better combination can possibly be imagined.

In the Adoption of Electric Street Railway Traffic America leads the world, and the extent of this most important application of electricity has grown with gigantic strides in a very few years. Three years ago electric railway statistics showed but thirteen electric roads in operation. Now there are more than three hundred and the number is increasing daily. In fact so many new lines are projected and so many companies are abandoning horses and cables in favor of electricity that by the end of this year the number of electric railways in the United States will probably exceed five hundred. The capital at present invested in these enterprises is more than $50,000,000. It was this marvellous development that caused the adoption of electricity on the new London road, which it was originally intended to operate by cable, and if America had not shown what could be done London would probably have hesitated before making the innovation. Hitherto New York has been blind to the advantages of electric traction and many New Yorkers have never even seen an electric railway proper, although the storage battery car is now a familiar sight to most who travel by the East side. Now there can be no doubt that electric rapid transit has got to come and New York wants the best and biggest and fastest system that civil and electrical engineers can give her—and she wants it just as soon as she can get it.

The Thirteenth Semi-annual Convention of the National Electric Light Association was held at Providence late in February, and was one of the most successful and largely attended gatherings in the history of the Association. Among the technical papers read was an elaborate study of "The Electric Arc and Its Use in Lighting," by Prof. Elihu Thompson; "The Distribution of Steam from Central Stations," by F. H. Prentiss, who put forth the suggestion that electric lighting companies might profitably supply steam as well as electricity and "Electric Light as Applied and Used by Steam Railroads," by W. H. Markland. An excellent description of the gigantic central station recently erected near London by Mr. S. Z. de Ferranti, for the supply of current at 10,000 volts pressure, was given by Caryl D. Haskins, who was for some time associated with Mr. Ferranti. From this paper it is evident that the Ferranti system is planned on thoroughly scientific and praccal lines, and no one can question that this formidable experiment deserves the success anticipated by its projector. Several other more technical papers were read. The fourteenth convention of the Association is to be held in Montreal in August next.

Central Station Electric Lighting in England is progressing very satisfactorily now that legislative obstructions have been removed. There are now ten important electric lighting companies at work in the British metropolis, several of which operate two or more central stations. Four of these stations employ the alternate current transformer system, and of these four two are Westinghouse stations entirely on the American plan. The remainder use the direct current low-tension system of distribution, in some cases in connection with sub-distributing stations containing storage battery plants, or continuous current transformers. The continuous current transformer is an interesting adjunct to direct current systems of distribution, but it has yet scarcely emerged from the experimental stage, although one has been used by the Chelsea Company in London for more than six months with fairly satisfactory results. It is curious to note that the London companies favor the use of 8 candle-power glow lamps rather than the more powerful lamps in general use in this country; it is claimed that a more even distribution of light can be obtained by means of the lamps of the lower denomination, and that the difference in brilliancy between the lamps themselves is scarcely apparent, while the saving in energy effected by adopting the smaller lamp is of course very great.

The First Stone of the London Subways which are to be used for the electric lighting mains in that city, was laid in February. The cost of the public lighting will exceed $100,000 a year; there will be installed for the street lighting 400 arc lamps of 2000 c. p. each, and 1000 20 candle-power incandescent lamps. The work has been divided between two companies, each of which will erect a model central station. It is expected that much private lighting will also be done, and the two stations will have an aggregate capacity of 1200 arc lamps, and 180,000 incandescents. In one of the stations Thomson-Houston apparatus will be used. It is estimated that the total cost of the plant will be not less than $5,000,000.

"Inductive Disturbances in Telephone Lines," was the title of a paper read by Mr. J. J. Carty, Electrician of the Metropolitan Telephone Company, at the last meeting of the American Institute of Electrical Engineers. Mr. Carty discussed not the disturbances produced by foreign wires, such as those of telegraph and electric light circuits, but the induction known among telephone engineers as "cross-talk, *i. e.*, the induction from one telephone circuit to another, resulting in the straying of conversation being carried on over one wire into the instruments connected with its neighbor. In this kind of inductive action the induced currents flow in opposite directions from a certain point, which thus becomes a neutral point, and a telephone inserted in the line at this situation will be perfectly silent, while those at either end are affected by the disturbing currents. A number of experiments have been made to prove the existence of this peculiar phenomenon, and the practi-

cal bearing of the discovery is applied in the construction of long-distance telephone lines, in which the relative position of the wires is changed at fixed intervals in order to distribute the induced currents and lessen or altogether neutralize their disturbing effect on the instruments connected in the various circuits.

A "Rapid Transit" Dinner was given at the New York Electric Club last month, the object of the gathering being to further the interests of electric rapid transit for New York City. The tenor of the speeches was that electric power has reached a highly developed state, and that in all new schemes it must be adopted wherever the circumstances are favorable. For dealing satisfactorily with New York's rapid transit problems it is particularly adapted. One of the speakers related an episode which occurred during the construction of the London electric underground road. The company was requested by the city authorities to notify them before the tunnel reached a certain point, near the buttress of London Bridge, as it was feared that a settlement might take place. In reply they were informed that the tunnel was already advanced a quarter of a mile beyond the point in question! As no effects of the tunneling had been observed further notifications of the progress of the work were not demanded.

An Interesting Model of an Electric Railway no less than fifty-five years old has recently been exhibited at the meetings of one or two of the scientific societies of New York. It is curious to learn to-day, when the electric motor can boast of a commercial career, dating back only a few years, that it was invented more than fifty years ago, and actually ante-dates Morse's telegraph instrument. The inventor was Thomas Davenport, a Vermont blacksmith. To Mr. Franklin Leonard Pope belongs the honor of making public Davenport's history and experiments in electricity. The results of Mr. Pope's researches have been embodied in a series of articles of fascinating interest contributed to the *Electrical Engineer*. Davenport heard of the experiments of Professor Henry with electro-magnets, and he obtained a specimen magnet with which to experiment for himself. Between 1834 and 1840 he built over 100 electric motors of different patterns and varying sizes, scarcely any two of them alike. In 1839 he built a motor of about one horse power, which he set up in New York for working a printing press; from that press was published the first electrical journal in the country and the first paper in the world printed by electrical power. It was called *The Electro Magnet and Mechanics' Intelligencer*. Davenport, however, was long before his time, and in spite of his ingenious inventions and marvellous progress, he died in comparative poverty. He could never induce capitalists to take any interest in his work, and his efforts at furthering the development of electrical science were practically wasted. If it had not been for Mr. Pope's investigations they would probably have remained entirely unknown to the present generation of electricians.

Some Interesting Experiments have recently been made by Mr. Nikola Tesla, in the production of alternate current dynamos with very high frequency, *i. e.*, a great number of alternations per second. In arc lighting with the alternating current difficulties are met with in maintaining a constant and silent arc, partly owing to the alternate heating and cooling, and consequent expansion and contraction, of the gaseous matter which forms the arc, corresponding with the periods or impulses of the current. Mr. Tesla believes that these difficulties could be done away with by using currents of a sufficiently high number of alternations, and so far his experiments have confirmed this belief. Some of the experimental generators that he has built are driven at a speed of sixteen hundred revolutions per minute, and produce ten or eleven thousand alternations per second. With a current of this nature a silent and constant arc light can be maintained. Other machines have been made giving the enormous number of 30,000 alternations per second. It is stated that the physiological effects of currents at a high rate of alternation are of a far less harmful nature than with currents of fewer alternations per second. Dr. Edward

Tatum, of Yonkers, N. Y., has made a number of experiments with a dynamo designed by Prof. Elihu Thomson, giving 8000 alternations per second, and he finds that the rapidly alternating current is not nearly so dangerous to life as the alternating current of lower frequency such as used in electric lighting practice to-day. A dog can be killed by a current giving 120 alternations per second at a pressure of 45 volts, but will survive a pressure of 450 volts when the alternations are as high as 8000 per second.

"High-Speed Electric Railway Work," is the title of a paper read before the American Institute of Electrical Engineers by Mr. O. T. Crosby. Experiments have been made by the Electro-Automatic Railway Company with the system invented by Mr. David G. Weems, which go to show that an electric railway working at the speed of 120 miles an hour is practicable and possible. This speed has actually been attained on an experimental track constructed at Laurel, Md. The car used was suitable only for carrying parcels and light freight, not being built to carry passengers; it consisted of a steel tube with pointed ends, to reduce the effect of wind pressure, supported by a pair of axles, a motor being geared to each axle. Mr. Crosby prophesies that the speed mentioned will be a matter of daily practice before very long. All the calculations have been made for another experimental line to be built on a larger scale for demonstrating the practicability of high speed electric railway working for regular passenger service. It will cost $300,000 to make the experiments, and it is satisfactory to note that the company expects to raise the funds necessary.

Opposition to Original Telephone Interests has already manifested itself in England, where the Bell telephone patent expired in December. Last month the Mutual Telephone Company opened its new exchange in Manchester with a small number of subscribers, the list being added to as rapidly as the work of constructing lines will permit. The carbon transmitter patents do not expire until July of this year, therefore the company is obliged at present to equip their instruments with magneto transmitters. These are of a special type, differing somewhat from the receivers, and are said to be very efficient. All the lines are metallic circuit, and the system of calling wires—which places the subscriber in direct communication with the operator by merely pressing a button—is employed. This system saves a great deal of time and the service is described as being excellent. The extremely low rate of £5.10 ($27.50) a year has been adopted. If the number of subscribers increases rapidly this rate can scarcely be maintained, as it is a well-known fact that the cost of operating a telephone exchange, increases *per line* with the increase of the number of lines connected.

The Pacific Cable is not to be laid yet apparently. It has been talked about for a long time, and several embryo companies are hovering about anxious to take hold of the work if they can only see their futures assured by means of liberal government subsidies. One of these made a bold effort to get a subsidy of $250,000 a year from the United States Government. The attempt failed completely, as after some discussion and a reduction of forty per cent. in the amount of the subsidy the bill was rejected. There is another American company willing to lay a system of cables 6000 miles long, to connect North America with the important groups of Pacific Islands, Japan and Australia, and this company asks no subsidy, merely the renewal of a charter which was granted some years ago but was allowed to lapse as the capitalists interested in the scheme had lost their faith in its merits as a money-making investment. It is to be hoped that the cable will be laid and operated by an American company, and that the American terminus of the line will be established in California, as the benefits to our trade in the Pacific would no doubt be great. If action is not taken soon, however, the cable will be laid from Canada by a British company. The line would be of strategic importance to Great Britain by affording direct communication between Canada and Australia. Its establishment has long been discussed and it is not improbable that the great cable companies

will soon take definite steps to put the project into execution.

Gutta Percha is Growing Scarcer and scarcer every year This gum is the most suitable material that can be used for insulating submarine wires, as it is practically indestructible in water and its insulating properties rather increase than otherwise with long periods of submersion. For many years submarine cable manufacturers have used it almost exclusively, and the price has gone up steadily, having more than doubled during the past ten years. The methods employed by the natives of the Malay Archipelago in collecting the gutta are barbarous in the extreme, and according to the investigations of a recent traveller, have resulted in the gradual extermination of the tree.

Electricity Generated by Water Power for driving drills, as applied in tunneling a distance of nearly ten miles through the Andes, is described in *Engineering*, (London), as follows: "Since August last a cataract of the Juncalillo River, which has a fall of nearly 600 feet, has been made use of to supply the power in carrying out the boring operations in the tunnels of Portillo, La Calavera, and La Cumbre. The water of the Juncalillo cataract is conveyed through steel pipes of half a meter in diameter for the distance of about a mile and is made to set in motion ten turbines, each of 80 horse power, which are connected with the electrical machines. The electricity thus produced is conducted through strong insulated copper cables to Juncalillo and Calavera. From Juncalillo air pressure machines are also supplied in the serpentine tunnel leading up to Portillo. From Calavera four 80 horse power dynamo machines generate the electricity for the Cumbre tunnel, where six borers, all working at the same time, are driven by eight air-pressure engines. On the Argentine side of the mountains another cataract near Navarro, has been similarly used for driving four turbines, each of 80 horse power. Owing to the distance of the western smaller portion of the Cumber tunnel, water cannot there be employed, and the borings are being carried out by hand. Wherever water and electricity can be used, the boring operations are performed, as it is estimated, fully four times as rapidly as they would be by hand. The cost and progress of the borings accomplished by this novel application of water power and electricity, cannot at present be estimated, but the figures, which will be made known on the completion of the undertaking, can scarcely fail to prove of considerable interest to the engineering profession.

Electric Propulsion of Boats, Bicycles, etc. by the Vauhan-Sherrin system, is attracting attention. The results attained are certainly very remarkable. The system comprises not only an improved motor, but what is more important an improved primary battery of high electromotive force, and great maintaining power and economy, the consumption of the zinc being, according to Prof. Sylvanus Thompson, very close to the theoretical limit. One of these cells only half filled at starting gave out an average electromotive force of 1.88 volts, and an average current of 8.75 amperes for five consecutive hours. It is a two-fluid battery with two replaceable anodes of sheet zinc and three fixed cathodes of specially prepared carbon. The plates are very light and are placed close together, thus making the resistance very small. The liquid in the inner cells is simply water. That in the outer cells surrounding the cathodes, is a depolarizing liquid of a peculiar composition not stated. The motor is a modified two-pole Gramme machine, having field magnets constructed in a special manner, which, while maintaining great mechanical strength, admits of perfect lamination of the iron. It is, when properly set, remarkably free from sparking at the commutator. It is also wonderfully light, a one horse-power motor giving only 62 lb. of dead weight. A launch 40 feet long has been fitted under this system for a 600-mile run. A launch of the same size would, fitted with steam, cost £400; with the accumulator, £700; with the "Sherrin," only £250.

MINING Accidents appear to have been epidemic during the last two or three months. The victims of explosions, floodings, etc., have been numerous, and in several cases the loss of life has been appalling. In general the risk to the life of miners in mining operations is about as great as that to the lives of soldiers in active service in proportion to the numbers respectively engaged in these occupations; yet, while we hear constant praises of military courage, little or nothing is said of the bravery of those who go down to delve in pits that we may be warmed and that our factories, railways, and steamships may be supplied with needed fuel. Is not the work of supplying the necessaries of life to our fellow creatures in peaceful homes as noble as that of slaughtering them on the field of battle? That these accidents have been so numerous of late is a clear indication of abated care and watchfulness on the part of those whose business is to foresee and remove causes of accident. Doubtless this rapid succession of catastrophes will stimulate owners, superintendents, and mining engineers to greater vigilance. This will last for a time, then gradually diminish until the conditions are established for another epidemic of disaster.

The Coke Industry of Alabama is now the third largest of any in the U. S. In Aug. 1890 it had 4607 ovens at work, and 340 more in process of construction. The output of the ovens for 1889, was a million tons. This product is substantially all used for iron-smelting for which purpose experience has shown it to be of good quality.

A New Tin Mine of remarkable richness is announced as discovered recently in an abandoned shaft of a mine near Durango, Mexico. It is a vein of cassiterite, through which the shaft had been cut, apparently without knowledge of the value of the vein. The discovery is said to have been made by a Californian, who found that the shaft, about 300 feet deep, had cut the vein. After running a horizontal tunnel for a short distance at the bottom of the shaft he struck a vein of ore four feet wide composed of a solid mass of oxide of tin, assaying from 50 to 60 per cent. of the pure metal. There is no sulphur in it, so that the work of reducing the ore simply amounts to smelting and casting into ingots. The mine was originally opened about one hundred years ago. It is said that a Scotch miner who has had a long experience in the mines at Cornwall, pronounces this the richest lead of tin ore he has ever seen.

The Facilities for Cheap Transportation on the Great Lakes having already borne such splendid fruits, are seen to have still further service to perform in the interest of the iron trade. The pressure of competition from other iron centres necessitates still greater reduction in freight rates, as is shown by the demands of Cleveland manufacturers. The highest rates which vesselmen can charge this season will not exceed the lowest of last season. Accompanying this reduction will be a lowering in the charges for "trimming" cargoes and for discharging, as also a decrease in rates on the railroads carrying ore from the mines to the upper lake ports.

A Remarkable Chimney has been designed for the royal smelting works of Saxony, by Herr Heneicke. Its dimensions are to be 23′ square inside measure at the base and 15½′ square at the top

which is to be 460 feet from the ground. Assuming the mean temperature of the gases in this chimney to be such that the weight of the column is one half that of a similar column of air at the exterior temperature, the draught will be that due to a pressure equal to 6.73 inches of water or about the same as is generated by a first-class foundry pressure blower, say about 150 feet per second, taking friction into account, and the volume discharged will be 2,070,000 cubic feet per hour.

The Chlorination of Gold Ores has developed until the conditions for success upon an economic basis seem to be well comprehended. The most striking improvement upon the old methods is in the application of sulphuretted hydrogen as a precipitant for the recovery of the gold from solution, the gold coming down as a sulphide. This method greatly cheapens the cost of precipitation, and offers a further advantage for certain classes of ores in that any arsenic or antimony which may be present is not thrown down from the cold solution until a considerable time after the gold. The sulphuretted hydrogen also precipitates copper, but this may be easily removed from the sulphide of gold by dilute nitric acid. The successful development of cheap methods for the chlorination of gold is of peculiar importance to our Southern States, where there are a large number of mines containing low grade sulphurous ores which can be profitably treated only by some such process as this. In fact there is an opportunity for creating a very considerable industry in various parts of the South by erecting custom chlorinating mills, to which ore from small properties could be sent for treatment. This would, of course, require "cobbing," or dressing of the ores, in order to make them pay after deducting transportation and mill charges, but the majority of Southern gold mines while too small for operations on a large scale, would yet pay if worked simply and cheaply by individuals rather than by companies, the roughly concentrated ores being treated at the custom mill.

Tin Mining in the Black Hills is stated to be in a promising condition by a correspondent of the New York *Sun*, who writes from Hill City, S. D., as follows: "The winze of the Gertie has been sunk 93 feet below the drift. At this point and for some feet above the lode is turning out tin-bearing rock assaying 22½, 40½, and 27 pounds of block tin to the ton. The lode is 16 inches wide at the south end of the winze and 20 inches wide at the north end. Tin ore of very fine quality is shown throughout the entire lead. At a depth of 102 feet it is from 18 to 26 inches wide. It widened from 6 to 8 inches in the last 9 feet of sinking. The average of block tin in the lode is about 4 per cent. Some specimens gave as high as 313 pounds to the long ton, or 14 per cent. At the Nevada Number Two mine the shaft has reached the ninety foot level, and sinking for a new level has begun. The drift from the east cross-cut is twenty-six feet long The tin-bearing portion of the lode is greatly increased in width, till it is now over four feet. The quality of the rock is improving. One specimen assayed over 123 pounds of block tin to the ton, or over five per cent. Others range from eighteen to thirty-six. The width of this lode is phenomenal, being eighty-two feet. The Colorow mine is producing very fine ore, assaying from two to four and a half per cent. This is at the depth of eighty-four feet. A rich seam of tin ore was struck on Feb. 6, carrying from one to six per cent. of block tin. The lode at the depth of eighty inches is five feet nine inches wide, and the rock soft and micaceous. The crystals are of a fine granular structure and average seventy-four per cent. of metallic tin.

The Three Great Coal Fields of Alabama, were described and discussed in an able lecture recently delivered before the American Geological Society by Prof. Henry McCalley, Assistant State Geologist of Alabama. These fields are respectively called the *Warrior*, the *Cahaba* and the *Coosa*. Their areas are: *Warrior*, 7800 square miles; *Cahaba*, 435 square miles, and the *Coosa* about 250 square miles. The *Warrior* field embraces all the coal measures drained by the Warrior and Tennessee rivers. The *Cahaba* is a

field about 15 miles in width at the widest part and about 60 miles long, lying in Central Alabama. The *Coosa* has a maximum width of about 6 miles and a length of 60 miles, and is the most southeastern of these coal measures. The coal measures of the *Warrior* are from 50 to 2500 feet in thickness in seams varying from 1 to 11 feet in thickness. The *Cahaba* measures have a maximum thickness of 5000 feet, with 49 seams having an average thickness of about 100 feet. With reference to the *Coosa* coal fields Prof. McCalley says that their maximum thickness is something like 2500 feet, though over much the greater part of the field these measures are considerably less than 500 feet in thickness. With reference to the *Warrior* field, the lecturer stated that its coals can be mined as easily and as cheaply as any other coal field, because the physical features of the country, the small angle of dip of the coals and the structure of the coals are all conducive to easy and cheap mining. The transportation facilities for a considerable portion of this field are now good. It has seven railroad connections, and also a river length within its basin of 100 miles that can be made navigable the year round for steam tugs and coal barges. The coals in the *Cahaba* field are cleaner and harder than those in the *Warrior*, having a bright shining lustre and being remarkable for purity and dryness; but their seams are much more inclined and faulty than those in the larger field. The *Coosa* is less known than the other fields. and its seams are thought to be mostly too thin for profitable working.

The Montignat Antimony Mines in the Department of Allier, formerly an important source of antimony, have been reopened under the auspices of Messrs. Lassalle and Brullot of Montluçon. The output for the past year aggregated 400 tons. The antimonial ores of Montignat are especially desirable on account of their freedom from arsenic and iron.

A Table of the Firing Points of Various Explosives, or the temperatures in centigrade degrees at which they are exploded, has been prepared by Mr. C. E. Munroe. The temperatures in the table are results obtained from about six experiments with each explosive, being the temperatures of a bath of paraffin or tin in which the explosive was placed and heated, and in which the bulb of a registering thermometer was also immersed:

Name and Description of Explosive.	Firing Point in° C.
Compressed military gun-cotton	186–201
Air-dried military gun-cotton..	179–186
" " " ..	186–189
" " " ..	137–139
" " " ..	154–161
Gun-cotton dried at 65° C....	139–131
Air-dried collodion gun-cotton	186–191
" " "	197–199
" " "	193–195
Air-dried gun-cotton.	192–197
" "	194–199
Hydro-nitrocellulose	201–213
Nitroglycerine.	203–205
Kieselghur dynamite, No. 1...	197–200
Explosive gelatin.....	203–209
Explosive gelatin, camphorated	174–182
Mercury fulminate.....	175–181
Gunpowder	278–287
Hill's picric powder.....	273–283
" " "	273–290
Forcite, No. 1..... ..	184–200
Atlas powder, 75 per cent.....	175–185
Emmensite, No. 1.....	167–184
Emmensite, No. 2...	165–177
Emmensite, No. 5.....	205–217

The Russian Petroleum Fields have for several years been a menace to our foreign trade in this product. As a competitor against American high grade illuminating fluids the Russian oil is accounted a failure on account of the heavy smoke evolved from its combustion. But as a fuel the Russian oil is becoming of great importance. It is being used with eminently satisfactory results on twelve Russian torpedo boats, for heating purposes on the vessels which ply in the Caspian Sea, and on many of the steam vessels on the Baltic. A system of pipe lines is in process of construction from Baku to the Black Sea, which will deliver sufficient oil to supply fuel for the entire marine of that sea. All the factories in Moscow have adopted it as fuel, the cost having been found to bear the ratio of 16 to 67 in favor of the oil. It has also been used to a limited extent in the French navy, and it bids fair to entirely supersede coal in the Italian navy, owing to her sources of coal supply being at a greater distance from Italy than will be the Russian oil upon the completion of the great Baku-Euxine pipe line. The en-

tire production of the Russian wells aggregated 900,000 barrels of 42 gallons each, in 1889. At the end of the year there were 239 wells actually producing; 39 were being cleaned; 136 new ones were in process of being drilled, and derricks were being erected preparatory to the drilling of 70 more. Nothwithstanding these increased field operations the output is gradually declining.

Sperrylite, so-called after the discoverer of this new mineral, offers a prospect of a much needed increase in our sources of platinum. This mineral is an arsenide of platinum, remarkable from the fact that it is the only known mineral containing platinum, outside of alloys of the platinum group. It was discovered in a placer among the copper and metal ores at Sudbury, in Ontario, on the line of the Canadian Pacific Railroad. The economical extraction of platinum from this mineral is a yet unsolved chemical problem, but in view of the ever increasing demand for platinum in the arts, already out of proportion to the supply, there would seem to be promise of reward to the chemist who will devise a practical and economical process for the treatment of this ore.

Smelting Works are being erected in Mexico as a result of the exclusion of Mexican silver-lead ores from the United States by the recent tariff regulations. A new smelting plant which will be ready for operations at Monterey in the early summer, will have a capacity of 500 tons of ore daily. It is also stated that the same company, the "Compañia Metallurgica Mexicana," proposes to build ten furnaces, owing to the extraordinary prospects for a large and profitable business. The supplies of ore for these works will come chiefly from Sierra Mojada, whence until lately many American smelting companies have derived their most important fluxing ores. It is worthy of note that the capital for this enterprise has been subscribed in the United States, and that while the mining industry is growing in Mexico, as a consequence of our tariff restrictions some of our own smelters have been obliged to suspend operations, and many others are seriously inconvenienced for the want of lead, thus increasing largely the cost of smelting.

The Electric Erygmascope is a new instrument for examining the character of strata cut through in rock-boring, a description of which, translated from the *Revue Industrielle*, is printed in *Scientific American Supplement*, No. 787.

The Annual Statistical Number of the *Engineering and Mining Journal* continues to challenge admiration and comment in every quarter of the globe. Mr. C. Le Neve Foster, professor of mining, and one of the Queen's inspectors of mines, delivered at the Royal College of Science, London, on January 19, 1891, a lecture on the progress of the art of mining, in which he said: "Before concluding my remarks upon the United States, I must express my admiration of their journalistic enterprise. I refer to the Annual Statistical Number of the *Engineering and Mining Journal*, of New York, dated January 3d, which reached me two days ago, giving very complete mineral statistics of their great continent. Knowing from actual experience the labor entailed in collecting and preparing such statistics, I can form some estimate of the difficulties that had to be overcome; and when a private firm accomplishes a task which no government in Europe has ever thought possible, viz., the publication of its mineral statistics within three days after the completion of a year, the meed of praise should be full and unstinted."

Rock Salt in Tully, N. Y., is discussed in the annual report of P. E. Engelhardt, Ph. D., Superintendent of the Onondaga Salt Reservation. The decline of the salt industry on the Reservation, he attributes to the expense of evaporating brine of 70° salameter strength, as compared with that of evaporating saturated brine, there being so far as cost of fuel is concerned an advantage of 33 per cent. against which manufacturers using the weaker brine cannot compete. He states, however, "that seventeen miles south of this reservation there is an inexhaustible supply of the best kind of rock salt which can furnish the Onondaga manufacturers with saturated brine in any quantity for almost all time to come.

The town of Tully, in which is situated the rock-salt deposit which furnishes the Solvay Process Company with its brine, is situated in the southern portion of Onondaga County. The town, containing four lakes, is surrounded by hills of considerable size and extent. The artificial outlet of Crooked Lake, which formerly formed the beginning of Onondaga Creek, is at present used by the Solvay Company to furnish the fresh water for dissolving the rock salt in its wells. Of the necessity of an abundant fresh-water supply for the solution of rock-salt, if the layers above the salt deposit furnish none, it is unnecessary to speak at length; but the advantage of the Tully locality above any other in the United States, as far as I know, is such that it deserves more than a common notice. The Tully lakes are some 800 feet above Syracuse, while the twenty-one wells used by the Solvay Process Co. (in the sinking of which the rock-salt deposit has been revealed), are about three hundred feet below these lakes, so that the water from these lakes not only furnishes the solvent of the rock-salt, but also the power by which the saturated brine is forced to the surface and into a reservoir, whence it runs by gravity to Syracuse. This advantage cannot be overestimated, since it does away with the expense of pumping the brine. The lakes on the Tully hills, four in number, comprise an area of 537.7 acres available water estimated at from five to six million gallons daily. The upper layer of this rock salt deposit is 43 feet thick and is separated from another layer 54 feet thick by a shale stratum 25 feet thick."

Death Valley in Inyo County, in the southeastern part of California, was described in the New York *Sun* of March 15, by Mr. J. J. McGillivray, a civil engineer of New York City, who explored it in search of mineral deposits. The valley had, and still has a most uncanny reputation, indicated by its name, which appears very appropriate in view of this description of its features. Surely a region where rain never falls, where the thermometer rises frequently to 130° F. in the shade,—where there is no verdure, and no water springs except those saturated with alkali,—where there are no living things except gnats, tarantulas, scorpions, lizards, rattlesnakes, and horned toads, and wherein all but two of the first party attempting a systematic exploration of its arid deserts left their bones, is a veritable "Valley of Death." Such are the characteristics of the central portion of this region wherein mirages are almost constantly misleading the traveller courageous enough to enter its forbidden recesses, yet wherein has been supposed to lie large deposits of valuable minerals, to search for which Mr. McGillivray was commissioned by New York capitalists. The mineral deposits sought, were those of the sodium biborate with which the waters of the lakes in the region are impregnated. He found, he avers, the richest and most extensive deposits of borax in the world on the east side of the valley. He adds that "These deposits are not worked just now because others nearer to the railroads are available. It seems strange that these deposits should have existed for so many years unappreciated. They lie on the surface, and must have been seen by the officers of the United States military survey in 1871, and by various prospecting parties that have visited this region."

The Formation of Petroleum from the decomposition of marine animals is claimed to have been proved by researches of Engler, published in *Chem. Zeit.* The process of formation is the decomposition of nitrogenous organic matters with evolution of ammonia and the fats, under the influence of heat and pressure into glycerol and fatty acids; the first is washed away, and the latter are further decomposed with formation of hydrocarbons and water. Engler considers the production of carbon dioxide and carbon monoxide in the conversion of fish oil into petroleum to be the result of a secondary reaction, as these bodies occur only in very small quantities in petroleum, and the less of these gases formed the more regularly is the reaction considered to proceed. Engler's experiments can also be explained in another way. The conversion of fats into hydrocarbons may be brought about as follows: The fat is first decomposed into glycerol and fatty

acids. The glycerol is then converted under the influence of heat and pressure into acrolein, and by the elimination of water and condensation this is converted into benzine, while the fatty acids under the same conditions are converted into hydrocarbons and carbon dioxide. The carbon dioxide under the influence of dissociated hydrocarbons is reduced to carbon monoxide, and ultimately to volatile hydrocarbons. The author thus considers that when gaseous hydrocarbons are found associated with petroleum they are formed from carbon dioxide as above; when they are absent he considers that the carbon dioxide has been absorbed by basic earths, with production of carbonates.

Ores of Nickel and Chromium recently discovered in Silesia, in the vicinity of Frankenstein, are said to prove very rich and abundant. It is also asserted that the owners of the mines have been offered for the property the sum of 1,500,000 marks.

Escape of Fire Damp in Mines and Barometric pressure are now thought by some to have a mutual relation. Herr Köhler, a German engineer, has been studying the subject at the Kohlscheid mines near Aachan, and he now states that he is compelled to admit such a relation. Sometimes barometric falls appear to be without influence upon the amount of fire damp present; but, in general, a maximum barometric pressure is accompanied by a minimum of the gas present in the mine. The effect is much more notable in summer than in winter.

A Great Metallurgical Feat was recently accomplished by a steel manufacturing establishment at Cleveland, Ohio, if it be true as stated, that it rolled at a single heat a twenty inch square steel ingot, weighing 8500 pounds after rolling into a plate ¼″ thick. Such a plate would contain somewhat more than 280 square feet, and, if 7 feet wide, would be 40 feet long.

Shipments of Copper from Portage Lake for the season of 1890 reached a grand total of 74,760,030 pounds. Of this total the largest shipment was from the Calumet and Hecla mine, 43,321,768 pounds, and the smallest from the Hilton, 12,680 pounds.

Quartz Yielding Only One Dollar per Ton is now said to be profitably worked at the Spanish mine, Nevada County, Cal. The average cost of working was there found to be 57½ cents a ton, 23 cents of which was for milling. At the Delmatia mine, near Auburn, Eldorado County, Cal., a large body of salt ore, which is said to carry from $1.50 to $2 a ton in gold, was profitably worked. Superintendent Pearson reports that 42½ cents covers the whole cost of mining and milling.

The Deepest Earth-Boring ever made is said on good authority to be in Saxony, where it was executed by the Prussian administration of mines for exploration near Kötschau on the Corbetha-Leipzig railway line. It has taken three years and six months to complete this boring with a hollow diamond rock drill. The bore-hole is 280 millimeters in diameter at the top, 48 millimeters at the bottom, and 1390 meters in depth, or about 4560 feet.

Deaths from Explosions in British Coal Mines for 1890 amounted to 285. Of these 273 occurred in the South Wales mining district and in nearly every instance were the result of using naked lights or from blasting.

Coal Mining in California is on the increase. So far the coal mined is of inferior quality but it nevertheless finds a ready market from the anxiety to obtain cheap coal. The principal sources of coal in the State are the counties of Mendocino, Monterey and San Bernardino, together with the Black Diamond Mine.

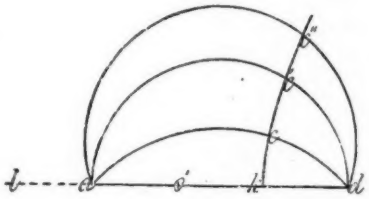
A Four Thousand Dollar Chunk of Ore was recently blasted out of the foot wall in Lamartine mine in Colorado. It measured about 7x11x4 feet, weighed 20 tons, and was valued as above stated.

A Mine of Mica has been found in South Australia. The quality is extraordinary, the sizes being asserted to average 9″x12″ in a shipment sent to Port Adelaide, and some of the plates being 24″x12″. Indeed one plate is said to have measured 32″x10″. The value of this quality of mica shipped to London, will be about 15 shillings per pound, at which rate a ton of the material will be worth £1500, or over $7000.

MR. DEPEW on the Car Stove is not quite so edifying as entertaining, though this may be said of many of his reported interviews. He believes (that is to say he is quoted as believing) car-stoves to be safer than steam or hot water for heating trains. Now if this conspicuous railway official would strive to be a little more perspicuous in his statements, it is possible he could enlighten the engineering profession on the subject of the combustion of railway cars and the ignition of wood-work in jets of escaping steam. This phenomenon has hitherto escaped attention. Also, the public will be much interested to know, by what process of reasoning he arrives at the conclusion that the local scalding of one or two people by a steam-jet from a ruptured pipe, is a greater calamity than the conflagration of a wrecked train in which a score or two of maimed and helpless people may be inextricably entrapped.

Hardening and Tempering Copper as recently discovered and brought into practice, has overcome one of the drawbacks of that metal in its natural state, and also the objections to its alloys as applied to use for bearings in machinery.

The Trisection of an Angle, that famous problem, the solution of which has been sought since the days of Archimedes, and which the French Academy many years ago pronounced impossible to be solved, has been solved in a simple manner by Mr. Frederic B. Honey, Ph. B., of Yale University. Any one who knows how to construct an hyperbola when its foci are given, can perform the operation by construction. As a matter of much interest to draughtsmen and constructing engineers, the solution by construction is here given: Draw $a\ d$ the chord of the arc $a\ c\ d$. Trisect $a\ d$ at o' and k. Produce $d\ a$ to l, making $a\ l = a\ o' = o'\ k = k\ d$. With $a\ k$ as a transverse axis, and l and d as foci,



construct the branch of the hyperbola $k\ c\ c'\ c''$, which will intersect all arcs having the common chord $a\ d$ at c, c', c'', etc., makings the arcs $c\ d, c'd, c''\ d$, etc., respectively, equal to one-third of the arcs $a\ c\ d, a\ c'\ d, a\ c''\ d$, etc. Of course the trisection of an arc also implies the trisection of the angle subtended by the arc.

A Thermometer with Electric Transmission is the title of an article published in *Le Genie Civil*, of which a translation is published in *Sci. Am. Supplement* No. 785. The article is a rather long one, containing a full illustrated description of what appears to be a valuable addition to our stock of instruments for physical investigations, as well as of practical utility in breweries, cold storage warehouses, etc. This instrument is capable of transmitting its readings to any distance and consists of two distinct parts, viz.: a transmitter or ther-

mometer properly so called and an electric receiver. The transmitter may be employed alone for direct and single readings, or it may be combined with one or more receivers for single or multiple readings at a distance. The receiver is a voltametre of special construction. The action of the transmitter is based upon the well-known expansibility of zinc when heated, the motion of expansion or contraction being transmitted to a needle by a small rack and pinion movement. The needle moving over a dial indicates the temperature and the electrical part of the apparatus simply repeats at a distance these indications.

The Heaviest Locomotive ever built so far as at present advised, was quite recently shipped from the Baldwin Locomotive Works to the St. Clair Tunnel Company being one of four of the same class ordered by this company, each of which are guaranteed to haul 760 gross tons of cars and load up a gradient of 105 feet to the mile. They are known as tank locomotives, and have no tender. The tanks are on both sides of the boiler, and their capacity is 2000 gallons. The space for the fuel, which is anthracite coal, is on the footboard. There are five pairs of driving wheels, which are the only wheels, and they are 50 inches in diameter. The wheel base is eighteen feet 3 inches. The cylinders are 22 inches in diameter and have a stroke of 28 inches. The boiler is of steel, ⅝ of an inch thick, and is 6 feet 2 inches in diameter. There are 280 flues, 2¼ inches in diameter and 13 feet 6 inches long. The firebox is 11 feet long and 3½ feet wide. The cab is placed on top of the boiler and midway between its ends. There are two sand boxes, one on the front of the boiler and one on the back, so that sand can be placed on the rails whether the locomotive is running forward or backward. There is a powerful air brake which operates on each driving wheel. There are headlights and steps at both ends, like those of a shifting engine. The locomotive will run on 100-pound rails. In working order the weight is 195,000 pounds.

The Courage of American Manufacturers in attacking new mechanical problems probably never had a better exemplification than in the readiness with which the Superior Mill at Allegheny accepted a recent order already declined by the principal English and European rolling mills, and the success with which at the very first attempt it executed the work undertaken, which was the unprecedented task of rolling and tempering a steel spring 310′ long, ¼″ thick and 6″ wide, designed for storing power in a novel car motor. This is undoubtedly the largest flat coiled spring ever yet made, yet the difficulties which our transatlantic cousins shrunk from were all successfully met and surmounted at the first trial.

A New Submarine Gun, invented by the son of the celebrated Toselli, is noticed in the Turin *Gazette*. The gun discharged at a depth of 100 meters penetrates this thickness of water in 10 seconds. The object of the gun is stated not to be the destruction of hostile vessels by penetrating their hulls, but in coast and harbor defense to destroy vessels by the concussion and violent disturbance of the water upon which they float over such submerged guns. Such a gun can be sunk in a channel or water approach and fired by electricity from the land, with the result of capsizing or foundering any vessel over it at the instant of discharge. With the modern position finder, the instant for the discharge may be exactly determined.

The Effect of Copper upon Rubber has been studied by Prof. Dewar, and his investigations have brought some valuable facts to light. Those who have had to use rubber packings in contact with copper or an alloy of copper in air compressors, have often noticed the peculiar condition of such packings after short use in positions where they are subjected to heat, as under the bonnets of the outlet valves of air-compressers, in ice-machines, etc. Prof. Dewar has shown that contact of rubber with copper, either alloyed with zinc or tin, as in brass, etc., or by itself, causes the rubber to rapidly decay, this being the result of a remarkable oxidizing action set up apparently by simple contact, as analysis of the decayed rubber shows no trace of copper present in it. The action always

takes place at temperatures of 150° F. and upward. At 150° F. the same rubber in contact with glass, platinum or zinc, remains unaltered. It would appear, therefore, that rubber or its compositions are not proper packings for heated joints of copper and brass.

Two Prizes of 3000 Marks each are offered by the Verein Deutscher Ingenieure, for the best essay on either of the following subjects: "What apparatus and devices have been applied to steam boilers for the purpose of reducing the smoke?" and "What apparatus and devices have been put into use in domestic and industrial establishments, especially in large cities, to obtain combustion with least smoke?" The second subject also involves an estimate of the relative perfection of the arrangements adopted for the steam boiler, and in domestic use. It is desired that critical mention of what has been accomplished in this direction in the past shall be made, and that, of the recent devices described, details and estimates shall be given, together with the practical results of efforts to comply with the regulations and laws of various municipalities with reference to the smoke nuisance. The expense incurred in preparing illustrative drawings will be reimbursed to the prize winners up to the limit of an additional 1000 marks in each case. The essays must be written in German, and addressed to the Verein Deutscher Ingenieure, Potsdammerstrasse, 131, W., Berlin, Germany. The time expires for the first subject on December 31, 1892, and for the second on December 31, 1894.

An Extraordinary Prize from the French Government has been offered for the year 1891 to any one who will invent any improvement that will increase the efficiency of the French naval forces. The prize is 6000 francs.

The Cutlery Trade of Sheffield, England, with the United States, according to statistics made public by Hon. Benj. Folsom, United States Consul, has fallen off about 60% since the operation of the McKinley tariff due in large measure, perhaps, to the heavy importations previous to the passage of the measure.

Aluminum Alloys have been made the subject of recent and careful experimental study by the Department of Aerial Navigation for military purposes at Chally in France. It was found that an alloy of aluminum with 2% of copper has a specific gravity only about 5% greater than that of aluminum, while the tensile strength of the alloy is 30.7 kilos per square mm. as compared with 18.7 kilos, the tensile strength of unalloyed aluminum. What is remarkable about this result is the much smaller increase of the specific gravity than could be anticipated by previous calculation which gives a theoretical increase of 12%. The copper in the act of combination therefore assumes a condition of density less than that of unalloyed copper. When 6% of copper is alloyed with aluminum the tensile strength is increased to more than double that of unalloyed aluminum, while the specific gravity is only increased from 2.67 (the density of hammered alumina) to 2.82. These alloys, therefore, present a remarkable increase of strength, with but a trifling increase in weight.

A Cement for Iron which will stand even so severe a test as the blows of a steam hammer can be made by mixing equal parts of sulphur and white lead with about one-sixth proportion of borax. This powder should be wetted with sulphuric acid and applied in a thin layer between the two surfaces of metal to be connected, which should then be pressed tightly together. The cement will dry in two or three days, when the joint will be found to be perfect.

Tannic Acid in Boiler-Cleaning Compounds, has been made the subject of investigation by the French chemist, M. Leo Vignon. He concludes that neither this acid nor any vegetable extract containing it is efficacious as a preventer or remover of scale in boilers, but considers that, owing to their coloration, and the amount of extractive matter they contain, they are simply employed to disguise the real nature of the solution; as serving to complicate the analytical examination of the solution, and to puzzle any chemist sufficiently bold to wish to discover their

secret. However if the acid is free it attacks the iron and therefore ought not to be used for boiler cleaning. M. Vignon regards this as completely proved by the results of a long series of experiments with iron plates subjected to the action of tannin and mixtures containing it under conditions as nearly like those to which boiler plates are exposed, as could be established in laboratory work.

Soldering Metal to Glass can be accomplished by first coating the glass where it is to be soldered with platinum, and causing the latter to adhere to the glass by bringing the latter into a state of incipient fusion. M. Cailletet (celebrated in the scientific world for his experiments in the liquefaction of gases) invented the process and communicated it to the French Physical Society. The application of the platinum is made by painting the glass, after slightly warming it, with a neutralized solution of platinic chloride mixed with the essential oil of camomile. The layer of oil and platinic chloride is then slowly heated till the last traces of oil have been expelled, and the temperature is then raised to a dark red heat. The chloride is thus reduced, and the platinum deposited as a bright metallic mirror on the surface of the glass. On this layer of platinum a second layer of copper is deposited by electrolysis and a metal stop-cock or tube can then be soldered by means of tin to this copper ring. M. Cailletet states that he has found these joints to remain tight under a pressure of 300 atmospheres.

A Week's Work in Birmingham, England, comprises among its various results, the fabrication of 14,000,000 pens, 6000 bedsteads, 7000 guns, 300,000,000 cut nails, 1,000,000 buttons, 1000 saddles, 5,000,000 copper or bronze coins, 20,000 spectacles, six tons of papier-maché wares, over £30,000 worth of jewelry, 4000 miles of iron and steel wire, 10 tons of pins, 5 tons of half-pins and hooks and eyes, 130,000 gross of screws for woodwork, 500 tons of nuts and screw-bolts and spikes, 50 tons of wrought iron hinges, 350 miles length of wax for vestas, 40 tons of refined metal, 40 tons of German silver, 1000 dozen of fenders, 3500 bellows, 800 tons of brass and copper wares, to say nothing of the myriad other articles, such as pianofortes, cylinder castings, perambulators, wheels, axles, safes, locks, etc.

The State of Carbon in Steel after tempering may be determined by the electrical resistance of the metal, as has been proved by the experiments of M. H. Le Chatelier, by which he ascertains the amount of carbon transformed in the process of tempering. This discovery opens the way to future investigation of the physical, chemical, and molecular character of tempered steel as compared with that of steel prior to tempering and hardening. Beyond the facts known to all mechanics that certain physical changes result from the heating, sudden cooling and subsequent tempering of steel, very little has been discovered, and the *modus operandi* of these processes is not yet well understood.

The Soldering of Aluminum can now be accomplished by either hard or soft solder, pure zinc, or an alloy of aluminum and zinc, by the use of a blow-pipe and a new patented salt as a flux. This is stated on the authority of Mr. Alfred Hunt of Pittsburg, an expert in matters pertaining to this metal. It is presumed that this flux is either already, or will soon be in market.

Tracing-Paper for Drawing is made by the Austrian Hydrographic Bureau as follows: The sheet of paper being placed over the drawing to be copied, it is lightly rubbed with a ball of cotton saturated with pure benzine. The tracing can then be readily made, owing to the resulting transparency, and the benzine, on evaporating, leaves the paper opaque as before, and without any trace of odor. Absolute purity of the benzine, however, must be insisted upon to secure good results.

Truck Brasses made of six parts lead and one of antimony have been extensively tested on several roads, and the results indicate that the composition named is the best yet found for this purpose.

Wear of Gold Coin by handling has been investigated at the United States Mint, and it is found that the handling of 200 bags containing each $5000 (as in placing them upon or taking them off a truck) wears away $5 value.

THE Thrift of the Working Classes in this country has generally been compared unfavorably with that of the laboring populations of other countries, especially France, the people of which are proverbially provident. In view of the following statistics such comparisons seem no longer just. The amount of deposits in the savings banks of the six New England States, and in New York, New Jersey and Pennsylvania, during the year 1890, aggregated the enormous sum of $1,279,000,000, or an increase over the preceding year of $65,000,000. The population of these nine States is about 17,300,000 and the number of depositors last year was 3,520,000—an increase of 140,000 for the year. It will thus be seen that the increase in the total amount of deposits for the year was equal to about $18 for each depositor, or, to put it another way, the total savings for the year amounted to nearly $4 for each inhabitant.

Progress in Aerostation within a comparatively short period is thus summarized by Mr. Octave Chanute, President of the American Society of Civil Engineers. "A measurable success has been attained with navigable balloons. They have been driven 14 miles per hour, and it is probable that speeds of 25 to 30 miles an hour, or enough to go out when the wind blows less than a brisk gale, are even now in sight. Very much more speed than this is not likely to be obtained with balloons, for lack of sufficiently light motive power and because of unmanageable sizes. Much greater speeds can perhaps be attained eventually with aeroplanes. Recent investigations indicate this, but even a beginning is prevented by the lack of a light motor and by questions as to the stability of the apparatus, as well as to safe ways in gaining high initial velocities. Whether these difficulties will ever be overcome no one knows, but they indicate the direction for investigation and experiment, while the probable benefits to man of a solution of the problem are so great that they are well worth striving for.

"Success with aeroplanes, if it come at all, is likely to be promoted by the navigable balloon. It now seems not improbable that the course of development will consist, first, in improvements of the balloon, so as to enable it to stem the winds most usually prevailing, and then in using it to obtain the initial velocities required to float aeroplanes. Once the stability of the latter is well demonstrated, perhaps the gas-bag can be dispensed with altogether, and self-starting, self-landing machines substituted, which shall sail faster than any balloon ever can. If we are to judge of the future by the past, such improvements are likely to be won by successive stages, each fresh inventor adding something to what has been accomplished before; but still, when once a partial success is attained it is likely to attract so much attention that it is not impossible that improvements will follow each other so rapidly that some of the present generation will yet see men safely travelling through and on the air at speeds of 50 or 60 miles per hour."

An Anti-fouling Anti-corrosive Lacquer for ship's bottoms, applied to the Japanese war vessels, is beginning to attract much attention; and it really seems, that, in this lacquer a long-sought desideratum has been found. It is stated, that, upon docking the *Naniwa Kan* after nine months' service, her bottom was found perfectly clean and smooth. On the other hand the U. S. ship *Charleston*, modeled after the *Naniwa Kan*, after a voyage to Honolulu, became so foul on the bottom that she was unable to make half her scheduled speed. The Japanese ship had its bottom covered with the lacquer while the *Charleston*, four months previous, had received a coat of antifouling paint. So far, unless the Japanese have found it, nothing has been discovered that can replace copper sheathing as a preventive of fouling of ship's bottoms.

Various Mile Records are as follows:

The fastest mile run by a railroad train was made in 40¼ seconds.

The record for the fastest mile made on skates is 2 minutes 12 3-5 seconds.

The fastest mile made in rowing in a single boat took 5 minutes 1 second.

The fastest mile ever made by a running horse was run in 1 minute 35 seconds.

The fastest mile by a man on a tricycle was made in 2 minutes 49 2-5 seconds.

The fastest time on snowshoes for a mile is recorded as 5 minutes 39¾ seconds.

The best time for a mile by a man on a bicycle is recorded as 2 minutes 29 4-5 seconds.

The fastest mile ever made by a man swimming was done in 26 minutes 52 seconds.

The fastest mile ever accomplished by a man walking was made in 6 minutes 23 seconds.

In running, the fastest mile made by a man was accomplished in 4 minutes 12½ seconds.

Paper Torpedoes for naval defense have been experimented with in Germany with very promising results. Charges of twenty-pounds of dynamite are carried by these torpedoes and they are both propelled and fired by dynamite.

The Spreading of Burning Oil on water and the resulting hazard to vessels in harbors is said to be prevented by a device in use in several French harbors reported to work well. It is a chain of floating galvanized iron boxes, by which a portion of a harbor on which burning oil is spreading may be separated from the exterior and the fire confined within the line of boxes.

Large Shipments of Rubber Belting have, on the authority of the *India Rubber World* (New York), been made to Japan from this country during the past year. The journal quoted states that the Japanese government is actively engaged in the development of new industries. For instance, six paper mills have been established within a short time in that kingdom, under the supervision of young Japanese trained in paper making at Holyoke, Mass. All the machinery used is of the very best American manufacture, and the belting used is of rubber, the six mills having been supplied by one firm of rubber manufacturers here. This is but a single illustration of the new channels for the sale of American rubber goods.

The Applications of Electricity to the supply of the necessities and luxuries of life as given in the following summary from the New York *Sun* may, that journal thinks, sounds like a wild and exuberant flight of fancy, but it is simply a statement of reality.

"In some cities, so far has the use of electric motors gone, that it is possible for a man to-day to drink at breakfast coffee ground and eat fruit evaporated by electric power. During the morning he will conduct his business with electrically made pens and paper ruled by electricity, and make his records in electrically bound books, his seventh story office, in all probability being reached by an electric motor elevator. At luncheon he will be able to discuss sausages, butter, and bread, and at night eat ice cream and drink iced water due to the same electrical energy. He will ride all about the place in electric cars, wear shirts and collars mangled and ironed by electric motors, sport in a suit of clothes sewn and a hat blocked by the same means; on holidays ride a merry-go-round propelled by an electric motor, or have his toboggan hauled up the slide with equal facility; be called to church by an electrically tapped bell, sing hymns to the accompaniment of an electrically blown organ, be buried in a coffin of electric make, and, last of all, have his name carved on his tombstone by the same subtle, mysterious, all-persuasive and indefatigable agency."

Experiments to Determine the Force of Ocean Waves are described by a writer in the N. Y. *Sun* as having been made by an instrument called a *Marine Dyamometer*. It has a known surface for the water to impinge on, the force of the impact being transferred to springs of known strength. The distance to which the springs are compressed is self-registering. This instrument has recorded the force of the waves, not under extraordinary circumstances, as high as three tons to the square foot. No doubt, in exceptional cases the pressure has been more than double that figure.

A New Life-raft is described in the New York *Sun* which may be folded up so that it shall take up no more deck room than does an ordinary lifeboat, and which may, in fact, be made a chuck for the reception of the lifeboat; under this arrangement both boat and raft may, by an ingenious but simple contrivance for handling, be put overboard by the same set of davits, the raft following the boat so quickly that the two are set afloat within a couple of minutes of each other.

A Very Curious Phenomenon in the action of blocks of gun-cotton has been described by Professor Monroe in a recent lecture at Lowell, Mass. It was shown by the stereopticon that the letters U. S. N., with the date of manufacture, that are on the bottom of each block, are impressed upon an iron plate upon which the gun-cotton may be exploded. It is a curious fact that, if the marks on the block are in relief, the reproduction on the iron will be raised, and, if cut in, there will be an indentation on the plate. Professor Munroe's theory is that when the letters are cut into the explosive, the gases generated in the indentations are hurled from them as a projectile from a gun. If a leaf or a delicate piece of lace be laid between the gun-cotton and the iron, its impress will be left in all the perfection of outline of the original, though the article itself is absolutely annihilated. Professor Munroe declares gun-cotton the safest explosive in use. The blocks are prepared by successive compressions in hydraulic presses, the last and heaviest compression being 6800 pounds per square inch. Workmen shape these blocks for use in the U. S. Navy, by jig-sawing, turning in lathes and chiselling, and two thousand pounds have been burned in a bonfire without an explosion. It is exploded by detonators and one volume of the explosive gives 829 of the gas, the pressure developed by combustion being eighty-one tons to the square inch, and by detonation 157.5 tons, the latter being in contact, however. The effect of the explosion of one particle on another is so rapid that it would take only one second for it to pass through 19,000 feet of the explosive.

The Reduced Supply of Natural Gas and the return of manufacturers to coal as fuel is noticeable in many localities, particularly in Ohio, in which this has been done largely, especially in Columbus, Toledo, Dayton, Springfield and Urbana. In some localities the diminished supply is due to stoppage of the wells by solid deposits, which, when removed, show that the wells are nearly or quite as productive as ever, but the general indication is that the use of natural gas as a fuel for manufacturing purposes will ultimately cease.

A Curious Inclined Railway has been projected for ascending the celebrated Jungfrau. As proposed, it is to be two inclined tunnels, each 10′ in diameter, up which cylindrical cars with flanges exactly fitting the tunnels are to be propelled by compressed air forced into the space below them. This would seem in all respects, except the inclination of the tunnels, to be a revival of the pneumatic tunnel scheme, which some time between the years 1860 and 1870 was begun under Broadway at the corner of Warren Street, in New York City, and was scarcely begun before the work was discontinued. The small section of the tunnel then constructed is still at the point named, though very few citizens of New York know anything about it.

Aerial Navigation is placed among the near possibilities of engineering by Professor Hoadley of Swarthmore College, who has, after analysis of the subject, reached similar conclusions to those expressed by Mr. Chanute.

Lumbering in the Adirondacks as Affecting Water Supply has been graphically described by a correspondent of the Utica *Herald:* "Where they had lumbered around the small ponds we found the water greatly diminished, and in many cases great stretches of marsh have been found. The effect of lumbering in the case of mountain streams has been to form a sediment upon the stones; the water becomes discolored, and often unfit to drink, and this, too, where but a short time ago these streams were in fine condition, the clear water running over moss-covered rocks and gravel bottom. Where the lumbermen flood the stream and 'drive,' it not only gullies out the bed of the stream to a great extent, tearing away the banks and otherwise injuring its natural beauty, but, as a rule, since there is no shade left, all fishing is destroyed, and, the sunlight striking the bed of a brook left in such a condition with even the moss gone, evaporation is so rapid as to so lessen the water supply that unless the stream should lead where there was an abundance of green timber it would actually dry up during the summer. Soft timber affords a great deal of shade; so much that there is usually a heavy growth of moss in such places, especially on the mountain sides. The soil where spruce grows is very light, the roots growing near the surface. The result of cutting heavily in such timber is that the smaller trees left, as a rule, blow down, and the sunlight let in kills the moss. The disastrous effect of dams erected at the outlets of the larger lakes is to raise the water, killing the timber along the shore line, and producing large areas of marsh land."

A New Line of Ocean Steamers, which will make the time of crossing the Atlantic from Montauk Point to Milford Haven in England only 5 days, is said to be under consideration by Mr. Austin Corbin, and to have been rendered possible by the subsidy bill passed by the U. S. Congress at its last session. It is said that eight 12,000-ton steel ships, to be wholly built of American materials and in American yards will be placed on this line if the scheme be carried out. Mr. Corbin when recently interviewed on the subject, refused either to confirm or to deny this statement; but there is little doubt that such a scheme is "in the air."

The *City of New York* has proved to be the fleetest steamship on the Atlantic with the single exception of the *City of Paris;* and her recent performance leaves it extremely doubtful whether this exception should be made. On her trip, which ended with her arrival at New York on March 14th, she made an average of twenty-one miles an hour, and for four successive days she made respectively 485, 501, 500 and 503 miles,—a feat which has no precedent in Atlantic steam navigation. The entire voyage from Queenstown to Sandy Hook was made in six days, 2 hours and ten minutes, the whole distance sailed (2886 miles) being 111 miles more than her test passage. Allowing for the extra distance this is only one hour short of the best record made by the *City of Paris.*

Ammonia Water as an Extinguisher of Fire was put to a good test at a recent fire resulting from an explosion in a large chemical works and tar distillery at Hawarden, Eng. A still charged with anthracene oil, 10 tons in quantity, exploded with terrific force, owing to the choking of the worm, and shot a volume of flame skyward that illuminated the district over a wide area, and was visible 10 miles off. The burning oil scattered itself over the yard and to the pitch house adjoining, where hundreds of tons of pitch were stored. The pitch ignited, and the conflagration assumed alarming proportions. Luckily, all the day men had just left the works, but three who had been left were burned. The Sandycroft Fire Brigade was promptly on the spot, and, by using ammonia water from a 50,000 gallon tank, they subdued the fire in an hour and a half.

Machine Street-Sweeping in the city of New York has by actual comparison with the hand-broom or "*patrol*" system, been proved to cost only about half as much as the latter. *Per contra*, it is asserted that very much better results are attained by the "*patrol*" system.

Discussing Free Coinage recently Mr. Edward Atkinson said very forcibly: "The free coinage of silver should not meet with objection. There is no reason why the Government should not coin silver and certify to its weight and fineness. It is immaterial whether there is seignorage charged or not. There is only one little thing to be remembered. Coinage and legal tender are two things and not synonyms. There are two kinds of dollars as there are two kinds of weights. We have an avoirdupois pound containing 7000 grains, and a troy pound containing but 5760 grains. One dollar is worth 100 cents and the other but 80 cents. If the Government insists on avoirdupois weight, you will hear no more about free coinage. The owners of the silver mines want to put the troy pound on the Government and get the avoirdupois pound in return."

Climatological Periods having a duration of about 35 years have been pointed out by Professor Brückner of Berne, Switzerland. He says these periods are the more marked for interiors of continents; and he names, as centres of cold, wet periods, the years 1700, 1740, 1780, 1815, 1800 and 1880. Centres of warm dry periods are stated to be the years 1720, 1760, 1795, 1830 and 1860. He states that a cause of the warm periods, is the hindrance of the passage of oceanic air to interiors, thus diminishing rainfall; while the opposite condition attends the cold periods.

The End of the First Century of Patents in the United States, and the commencement of the second century is to be celebrated at Washington, April 8. Simultaneously with this celebration it is proposed to hold meetings for the organization of the National Association of Inventors and Manufacturers on the afternoon of April 7, and in the morning of April 8 and 9, and at such other times as may be necessary, upon which occasions addresses are also expected from prominent inventors and manufacturers. Among the papers announced are those by Maj. Clarence E. Dutton, O. D., U. S. A., upon "The Influence of Invention upon the Implements and Munitions of Modern Warfare;" Professor Thurston, late U.S. Navy, now director of Sibley College, Cornell University, on "The Inventors of the Steam Engine," and Dr. John S. Billings, on "Invention and Discovery in Surgery and Medical and Sanitary Science." Edward Atkinson, Ph. D., LL. D., of Massachusetts, "Invention in its Effects upon Household Economy;" Thomas Gray, C. E., B. Sc., F. R. S. E., of Indiana, Professor of Dynamic Engineering, Rose Polytechnic Institute, Terre Haute, "The Inventors of the Telegraph and Telephone;" Octave Chanute, of Illinois, President of the American Society of Civil Engineers, "The Effect of Invention upon the Railroad and Other Means of Intercommunication;" William P. Trowbridge, Ph. D., LL. D., of New York, Professor of Engineering, School of Mines, Columbia College, "The Effect of Technological Schools upon the Progress of Invention;" Cyrus F. Brackett, M. D., LL. D., of New Jersey, Henry Professor of Physics, College of New Jersey, Princeton, "The Effect of Invention upon the Progress of Electrical Science." Other eminent speakers will also address the meetings, and the occasion promises to be one of unusual interest.

Photography in Colors, a problem which has long engaged photographers shows signs of an approaching solution. Prof. Gabriel Lippmann, of the Paris Academy of Sciences, has succeeded in photographing the solar spectrum in colors. Though in his communication of his experiments to the Academy, he says the theory is very simple, it is so only to those well versed in the art of photography and in optical science.

A Nozzle Constructed to Act as a Water Meter was described at the regular meeting of the American Society of Civil Engineers, held February 18, by Mr. C. B. Brush, who stated that he was about to construct a nozzle of the kind described, and test it by continuous actual service which the members were invited to witness.

Loss of Property by Fire is footing up fast since the beginning of 1891. For January and February, it amounted in the United States to $16,500,000, a daily average of $289,824.

OUR EXCHANGE TABLE.

EDITORS and publishers are requested to send marked copies of special publications for mention in this department. The list of articles in this number is not so complete as we purpose to make it, for reasons that will readily suggest themselves. —ED.

SCIENCE: 10c. 47 Lafayette Place, New York.

Feb. 13. Scientific Results of Nansen's Journey Across Norway. Dr. Fridtjof Nansen.

Feb. 20. Report of Progress in Spectrum Work. From Johns Hopkins University Circulars.

Lightning-Rod Protection. N. D. C. Hodges.

SCIENTIFIC AMERICAN SUPPLEMENT: 10c. 361 Broadway, New York.

Feb. 21. Transmission of Messages Through the Air by Electricity Without Wires. (Illustrated.) John Trowbridge.

Feb. 28. The Power of Water, or Hydraulics Simplified. Runs through several numbers.

JOURNAL OF THE FRANKLIN INSTITUTE: 50c. The Franklin Institute, Philadelphia, Pa.

Feb. The Olsen Testing Machine.

Electricity. Its Past, Present and Future. Ralph W. Pope, Sec. Am. Inst. of Electrical Engineers.

Some Properties of Confocal Ellipses and their Application to Mechanism. Horace B. Gale.

High Explosives in Warfare. Commander F. N. Barber, U. S. N.

March. The Continuous Girder.—Variable Moments of Inertia.--Fixed Points. —Graphic Method. C. H. Lindenberger.

The Aluminum Problem. Joseph W. Richards, Instructor in Metallurgy, Mineralogy and Blow-Piping at Lehigh University.

PHILOSOPHICAL MAGAZINE: 2s. 6d. Red Lion Court, Fleet Street, London.

On Pinhole Photography. Lord Rayleigh, Sec. R. S.

The Problem of the Behavior of the Magnetic Field About a Revolving Magnet. S. Tolver Preston.

Alternate Current Condensers. John Swinburne.

Conductivity of Hot Gases. Prof. J. J. Thompson.

THE RAILWAY REVIEW: 10c. 189 Broadway, New York.

Feb. 21. The Ventilation of Tunnels. N. W. Eayres, Am. Soc. C. E.

Feb. 28. The Best Diameter of Car-Wheels. Samuel Porcher, Asst. Eng. Power Dept, Penn. R. R.

March 7. Railway Car-lighting. George Gibbs, M. E.

RAILROAD GAZETTE: 10c. 73 Broadway, New York.

Feb. 6. An Irregular Wear of Railway Ties. (Illustrated.) J. N. Barr, Supt. Motive Power, Chicago, Milwaukee & St. Paul R. R.

Feb. 13. The New Susquehanna River Bridge at Harrisburg, Pa. (Illustrated.) E. Chamberlain, Asst. Eng.

THE RAILWAY AND ENGINEERING JOURNAL: 25c.

March. The Development of the Compound System in Locomotives. (One of continued series. Illustrated.) From the French of M. Mallet. Trans. by Frederick Hobart.

The Submarine Mine and Torpedo in Harbor Defense. (One of a continued series.) First Lieut. Joseph O. M. Califf, Third U. S. Artillery.

IRONMONGER: 6d. 42 Cannon Street, London, E. C.

Feb. 7. Some Different Forms of Gas Furnaces.

The Mechanical Treatment of Moulding Sand. Walter Bagshaw.

IRON AGE: 10c. 96 to 101. Reade Street, New York.

March 5. Industrial Analysis. (One of a continued series.) August Rossi, C. E.

Improvements in Car-Wheels. P. H.

Griffin, Prest., New York Car-Wheel Works.

March 19. The Harvey Armor-Plate Results of Recent Trials at Annapolis. (Illustrated by Supplementry sheet of engravings.)

ELECTRICAL WORLD. 10c. Times Building, New York.

Feb. 7. The Construction and Use of Electrical Testing Apparatus. Charles P. Frey.

Electrical Equipment of our Squadron of Evolution. Lieut. Hamilton Hutchins.

Electricity in Transitu from Plenum to Vacuum. By Dr. William Crooks, F. R. S. (Continued March 14 and 21st.)

ARCHITECTURE AND BUILDING: 15c. 23 Warren Street, New York.

Feb. 28. A Scheme for Rapid Transit for New York City. (Illustrated.) Alfred H. Thorpe, Architect.

March 7. Color in Architecture, Mr. Alfred Waterhouse, R. A.

THE ENGINEERING AND BUILDING RECORD: 10c. 277 Pearl Street, New York.

March 7. System of Sewage Disposal for the Asylum for the Insane, London, Ont.

ARMY AND NAVY JOURNAL: 15c. 240 Broadway, New York.

Feb. 28. Table of Offences, and Punishments in The U. S. Army, as recently approved by the Secretary of War.

ENGINEERING AND MINING JOURNAL: 10c. 27 Park Place, New York.

March 7. The Pelton Water Wheel. (Tests at the University of California. Illustrated.)

Early History of Steam Navigation. (Abstract from a Chronical Lecture, by Mr. William Kent, Society of Mechanical Engineers.)

POPULAR SCIENCE MONTHLY: 50c. 1 to 5 Bond Street, New York.

March. The Relative Value of Cements, Charles D. Lameson and Hubert Remley.

SCIENTIFIC AMERICAN: 10c, 361 Broadway, New York.

Feb. 21. The U. S. Life Saving Service. (Illustrated.)

Feb. 28. Manufacture of Heavy Guns for U. S. Navy. (One of a continued series Illustrated.)

March 7. New Fire Boat for New York City.—The New Yorker. (Illustrated.)

THE ENGINEER (London) 6d. International News Co., 83 and 85 Duane Street, New York.

Feb. 20. H. M. Ships, *Royal Arthur* and *Royal Sovereign*. (Illustrated.)

A New Gun Mounting.

Feb. 27. Purification of the Seine. Syphons at the Isle of St. Louis, Paris. (Illustrated.)

Compound Worthington High Duty Pumping Engine. (Illustrated.)

ELECTRICAL ENGINEER: 10c. 150 Broadway, N. Y.

March. A Practical Guide to the Testing of Insulated Wires and Cables. Herbert Laws Webb. (One of a series.)

A New Storage Battery Plate, Stanley M. Currie.

NATURE 15c. 112 Fourth Avenue, New York.

Feb. 6. Huet's Anemometer. W. J. Lewis.

Feb. 12. Deductions from the Gaseous Theory of Solution. Prof. Orme Mason.

Feb. 26. An Automatic Lamp Lighter. Telford Bidweli.

THE AMERICAN JOURNAL OF GAS LIGHTING: 10c. 42 Pine Street, New York.

March 2. Laying Water Pipes Across Rivers.

March 9. An Easy Method of Finding the Units of Heat of Combustion in Gaseous Mixtures.

March 16. The Jones Gas-Fired Boiler. (Illustrated.)

THE ECONOMIST: 1s., 4d. London.

Feb. 21. English Railways in the Past Half Year.

Feb. 28. London Water Supply. (One of a series.)

March 7. The Argentine Debt Settlement.

THE PHOTOGRAPHIC NEWS: 3d. 5 Furnival Street, London.

March 6. New Discoveries in Heliochromy.

Photography in Germany.